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Research Article

Evaluation of okra (*Abelmoschus esculentus* L. Moench) genotypes for important quantitative characters

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ABSTRACT
An experiment was carried out during *kharif* 2017 at Zonal Research Station, Chianki using sixteen promising genotypes of okra with three replications in randomized block design. Observations on ten important quantitative characters were recorded. Analyzed data revealed that all characters showed significant effect. The genotype Ajeet-121 gave significantly highest yield with the yield of 135.12 q/ha followed by NS-862 and Super green with the yield of 134.75 q/ha and 134.02 q/ha, respectively. Average fruit weight (15.33 g) and yield of fruits per plant (245.67 g/plant) were recorded significantly highest in the genotype Ajeet-121. On the basis of these observations, it may be concluded that the genotype Ajeet-121 was found most suitable okra genotype for *kharif* cultivation in the western plateau region (sub zone-V) of Jharkhand.
Keywords: *Okra, Genotype, Evaluation, Quantitative characters*

INTRODUCTION
Okra (*Abelmoschus esculentus* L. Moench) belongs to the family Malvaceae having a chromosome number 2n = 2x = 130. Nutritive value of okra varies in different cultivars, which depends on the agro–climatic conditions. It contains protein, carbohydrate, vitamin C and other nutritive components which play a vital role in human diet (Kahlon *et al.,* 2007). Besides this, tender green pods of okra are important sources of vitamins A, B_1, B_3, B_6 and K, folic acid, potassium, magnesium, calcium and trace elements such as copper, manganese, iron, zinc, nickel, and iodine (Lee *et al.*, 2000), which are often lacking in the diet of people in most developing countries. The tender green pods are highly nutritious vegetable, containing 86.1% moisture, 9.7% carbohydrate, 2.2% protein, 0.2% fat, 1.0% fiber and 0.8% ash etc. (Saifullah and Rabbani, 2009). The tender green pods are also popular in most tropical and sub-tropical region of the world due to their medicinal values as they contain very high levels of antioxidants compounds including β-carotene, xanthin, lutein etc. (Rahman *et al.,* 2012). Okra commonly known as "lady's finger" and Bhindi in India is primarily suitable for cultivation as a garden crop as well as on large commercial farms. Okra is a popular vegetable grown almost all states of the country for its tender green fruits, which are cooked and commonly consumed as boiled vegetables and used in several recipe in Indian cousin (Chattopadhyay *et al.*, 2011). The crop performs very well in hot weather, especially in the regions with warm nights (Ndunguru and Rajabu, 2004). It is heat and drought-tolerant vegetable species in the world and will tolerate soils with heavy clay and intermittent moisture (Gundane *et al.,* 1995) but chilling temperature and frost and foggy weather can damage the crops; however, *kharif season* is the main growing season. In recent years, public sector and a number of private seed companies in India have been able to develop a good number of commercial cultivars, which are not suitable to all the regions of the country. They are varying in various characters from one region to another. Now today a large numbers of okra varieties/genotypes are available in the market which creates confusion among the farmers to select suitable one, all these are not adapted and suited to all the regions. No specific recommendations of variety all over the country in different agro-climatic zone. Farmers are facing problems in selecting genotypes for a particular area for commercial cultivation. Considering the above mentioned facts, there is a need to compare some of the available genotypes to select

high yielding, better adaptable genotypes for commercial cultivation. There is also lacking of suitable genotypes of okra for western plateau region of Jharkhand. Therefore, the present investigation was undertaken to identify superior and promising okra varieties/genotypes in respect to green fruit yield and other quantitative characters under western plateau condition of Jharkhand.

MATERIALS AND METHODS

An experiment was carried out at Zonal Research Station, Chianki of Birsa Agricultural University, Ranchi, Jharkhand, India during rainy season, 2017. This research station represents western plateau region of Jharkhand and geographically situated at an altitude of 222 meters above mean sea level. This region (sub-zone-V of Jharkhand) falls under sub-tropical climate with annual mean rainfall of 1179.3 mm and lies between 22.5° to 24.5° N latitude and 23.2° to 25.6° E longitude (Sah *et al.,* 2008). The experimental materials were comprised of sixteen promising genotypes/cultivars *viz.,* Ankur-41, Super green, NS-862, Ajeet-121, Tiger green, Pusa sawani, Local-1, BAU-1, BAU-2-2, BAU-2-3, BAU-2-4, BAU-3-3, BAU-3-4, BAU-4-1, BAU-5-1 and BAU-5-2. Field trial was laid out in randomized block design with three replications. Standard package of practices were followed to grow normal crops with the plot size 1.5 X 5.0 =7.5 m^2. Sowing was done in spacing of 50 cm X 25 cm with two seeds per hill on 20^{th} July, 2017. After germination excess plants were thinned out to maintain one plant at desired distance. During data recording and observations, 5 plants were randomly selected from each plot and observations were recorded on ten important quantitative characters *viz.,* plant height (cm), number of primary branches per plant, stem diameter (cm), days to first flowering, fruit length (cm), fruit diameter (cm), number of fruits per plant, average fruit weight (g), green fruit yield per plant (g) and green fruit yield per hectare (q) were recorded. Mean data of all characters were subjected to suitable statistical analysis as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Statistically analyzed mean data of the experiment revealed that all characters under observation gave significant effect. Growth and flowering characters depicted in table 1 whereas, fruit characters and green fruit yield depicted in table 2. The plant height is usually a good index of plant vigour which may contribute towards higher productivity (Pandey *et al.,* 2017). The mean values of plant height of different genotypes showed significant variations, ranged from 109.67 cm (NS-862) to 162.33 cm (Local-1). The national check variety Pusa Sawani (151.67 cm), Tiger green (151.0 cm), BAU-2-2 (159.33 cm) and BAU-2-4 (154.67 cm) were statistically at par with the local check variety Local-1. Increase in plant height might be due to longer intermodal length in tall genotype (Local-1) and smaller in dwarf genotype (NS-862). Similar observations were also reported by other workers with significant variations among the plant height of okra genotypes (Saifullah *et al.,* 2009, Pandey *et al.,* 2017).

The mean values for number of primary branches per plant revealed significant differences among the genotypes with the range of 1.40 in BAU-1 to 2.60 in BAU-3-4. Five genotypes *viz.,* Ajeet-121 (2.37), Pusa Sawani (2.30), BAU-2-3 (2.27), BAU-3-3 (2.47) and BAU-5-2 (2.23) were found statistically similar to the genotype BAU-3-4 and all these genotypes were performing better in comparison to local checks i.e. Local-1(2.17). Rest of the variety was found intermediate range for this character. The highest number of primary branches per plant might be due to the genetic makeup of the genotype and environmental effect might be the cause of this variation. Which are prevailed during the crop growth period (Pandey *et al.,* 2017). Variation in number of primary branches in different genotypes of okra was also reported by Shivaramegowda *et al*. (2016) and Tiwari (2001).

Diameter of stem is also an important index of vigorous growth of the plants which leads to get higher productivity. The mean values of stem diameter revealed significant differences among the genotypes with the range of 1.43 cm in NS-862 to 2.40 cm in Super green. Six other genotypes *viz.,* Ajeet-121 (2.27 cm), BAU-2-2 (2.13 cm), BAU-2-3 (2.37 cm), BAU-3-4 (2.23 cm), BAU-5-1 (2.23 cm) and BAU-5-2 (2.20 cm) which were statistically similar to the superior genotype Super green and all these six genotypes were performing better as compared to both the checks Pusa Sawani (1.93 cm) and Local- 1 (1.80 cm). Rests of the entries were performing with in intermediate results. Variation in stem diameter of okra genotypes were also observed by other research workers at different places (Shivaramegowda *et al.,* 2016; Pandey *et al.,* 2017).

Days to flowering is an important characters of okra as earlier flowering resulted early picking of marketable green fruits which generally fetching higher prices in the market. The mean values of first flowering was observed as significant variations among the genotypes of okra for first flowering after date of sowing (DAS) with range of 40.0 DAS in Tiger green to 46.67 DAS in BAU-1. The genotypes Ajeet-121 (41.33 DAS) and BAU-3-3 (41.67 DAS) were observed as statistically similar to the earliest flowering genotype Ajeet-121 and these genotypes were found earliest even national checks (Pusa Sawani) and local checks (Local-1) which were comparatively flowering late with the mean values of 44.00 DAS and 43.67 DAS, respectively. Early flowering might be due to the better adaptability and genetic performance of the genotypes (Pandey *et al.,* 2017). This result was inconsonance with the result of

Mahapatra *et al*. (2007) and Binalfew and Alemu (2016).

Fruit characteristics of any vegetable crops are important parameters to select a variety/genotype for its wider acceptability among the farming community as fruit shape, size, colour, tenderness, firmness etc. are very much appealing to the consumers in the market. Okra is also a popular vegetable crop and its green tender fruits with long straight firm fruits like by the consumers. So, fruit length and diameter are considerable traits during the genotypic evaluation process. As far as fruit length is concern, mean values of tender fruit length revealed that significant variations among the genotypes with the range of 10.70 cm to 13.30 cm. Significantly highest fruit length was recorded in the genotypes NS-862 (13.30 cm) and BAU-5-2(13.30 cm) followed by Super green (12.30 cm), Pusa Sawani (12.70 cm), Local-1 (12.30 cm), BAU-1 (13.00 cm), BAU-2-2 (13.00 cm), and BAU-3-3 (12.70 cm) which were statistically at par. This result might be due to the genetic makeup as well as environmental influence on the genotypes as reported by earlier workers (Pandey *et al.,* 2017; Singh *et al.,* 2017). The mean values of fruit diameter at tender stage were also revealed significant differences among the genotypes with the range of 1.33 cm (BAU-5-2) to 1.63 cm (BAU-1). Most of the genotypes showed statistically similar to the better performing genotypes except, Super green (1.37 cm), Pusa sawani (1.43 cm) and BAU-5-2 (1.33 cm). This result was in accordance with the result of Mahapatra *et al.,* (2007) and Pandey *et al.,* (2017).

Average fruit weight and number of fruit per plant are an important yield attributing characters in okra. The data recorded on average fruit weight revealed that significant variations among the genotypes with the range of 13.00 cm (BAU-2-3 and BAU-3-4) to 15.33 cm (Ajeet-121 and Pusa sawani). Most of the genotypes were observed as statistically similar to the better performing genotypes except, BAU-1 (13.33 cm), BAU-2-3 (13.00 cm) and BAU-3-4 (13.00 cm), which were found significantly lower values. This result might be due to higher fruit length and diameter as well as their genetic response to the environmental conditions (Muhammad *et al.,* 2001). Several other workers also reported similar results (Singh and Jain, 2006; Sarkar and Chattopadhayay, 2004; Mehta *et al.,* 2006; Koundinya *et al.,* 2013).

As far as number of fruits per plant is concern, the mean values of the data revealed significant variation among the genotypes with the range of 12.00 fruits per plant in Local-1 to 18.67 fruits per plant in BAU-2-3. There was no significant difference between the best performing genotype BAU-2-3 (18.67 fruits/plant) and Super green (17.00 fruits/plant). Rest of the genotype was observed in intermediate range of number of fruits per plant. Variation in number of fruits per plant might be due to the greater plant height, more number of branches per plant may get more space for fruit development (Pandey *et al.,* 2017) and similar reports also quoted by Singh and Jain (2002).

The mean values of data recorded on green fruit yield per plant exhibited significant variations among the genotypes with the range of 168.33 g/plant (Local-1) to 245.67 g/plant (Ajeet-121). Most of the genotypes observed that statistically similar to the best performing genotype Ajeet-121 (245.67 g/plant) except, Local-1 (168.33 g/plant) and BAU-3-3 (195.33 g/plant). Variations among the genotypes for yield per plant might be due to the number of fruits/plant, average fruit weight, fruit length and diameter, seed content of the fruits and less incidence of yellow vein mosaic virus. These results are in accordance with the result of Pandey *et al*. (2017), Mahapatra *et al*. (2007) and Singh and Jain (2002).

Ultimate goal of any crop plants cultivation is to get higher yield per hectare. Similarly, in okra green tender fruit yield per hectare is also most ultimate target of any growers. The mean values of green fruit yield per hectare exhibited significant variations among the genotypes with the range of 92.58 q/ha (Local-1) to 135.12 q/ha (Ajeet-121). Most of the genotypes were found statistically similar with respect to the yield per hectare except, Local-1 (92.58 q/ha) and BAU 3-4 (107.43 q/ha). The genotype Ajeet-121 gave significantly highest yield with value of 135.12 q/ha followed by NS 862 (134.75 q/ha) and Super green (134.02 q/ha).

The superior performance of these genotypes for pod yield was due to their higher ranking for number of pods per plant, weight of pods per plant, number of branches per plant, pod length, plant height and less infection of yellow vein mosaic virus, which caused greater assimilation of photosynthates. The inherent yield potential of these genotypes was also responsible for higher production of pods (Pandey *et al.,* 2017). The genotypes received better adaptability to the environment and get the congenial conditions for the better growth and development of the plant as well as for flowering and fruiting. These findings were also in accordance with the (Tiwari, 2001; Singh and Jain, 2006) that have reported better adaptation of the genotypes with environment and also get the variation among the genotypes for different characters. These observations were also confirming the finding of (Muhammad *et al.,* 2001) who has reported that plant height and number of green pods had the direct effect on total fruit yield.

Table 1: Growth and flowering characters of okra genotypes during *kharif* 2017

Genotypes	Plant Height (cm)	No. of Primary Branches /plant	Stem Diameter (cm)	Days to First Flowering
Ankur-41	112.67	1.60	1.70	42.00
Super green	124.33	1.47	2.40	44.33
NS-862	109.67	2.20	1.43	45.67
Ajeet-121	126.67	2.37	2.27	41.33
Tiger green	151.00	1.53	1.77	40.00
Pusa Sawani (NC)	151.67	2.30	1.93	44.00
Local-1(LC)	162.33	2.17	1.80	43.67
BAU-1	127.67	1.40	2.00	46.67
BAU-2-2	159.33	1.53	2.13	44.67
BAU-2-3	120.33	2.27	2.37	46.67
BAU-2-4	154.67	1.67	1.47	43.67
BAU-3-3	137.33	2.47	1.72	41.67
BAU-3-4	143.33	2.60	2.23	44.00
BAU-4-1	128.00	1.60	1.67	43.00
BAU-5-1	148.33	1.87	2.23	46.33
BAU-5-2	129.00	2.23	2.20	43.33
CD (5%)	12.43	0.37	0.27	1.99
SE(d)	6.059	0.178	0.133	0.968
SE(m)	4.285	0.126	0.094	0,685
CV %	5.43	11.14	8.32	2.71

Table 2: Fruit characters and fruit yield of okra genotypes during *kharif* 2017

Genotypes	Fruit Length (cm)	Fruit Diameter (cm)	Average Weight of Fruits (g)	No of Fruits /Plant	Green Fruit Yield /Plant (g)	Green Fruit Yield /ha (q)
Ankur-41	11.3	1.47	15.00	15.33	229.67	126.32
Super green	12.3	1.37	14.33	17.00	243.67	134.02
NS-862	13.3	1.60	15.00	16.33	245.00	134.75
Ajeet-121	12.0	1.60	15.33	16.00	245.67	135.12
Tiger green	10.7	1.47	14.00	16.00	224.33	123.38
Pusa Sawani (NC)	12.7	1.43	15.33	15.00	230.33	126.68
Local-1 (LC)	12.3	1.47	14.00	12.00	168.33	92.58
BAU-1	13.0	1.63	13.33	16.00	213.00	117.15
BAU-2-2	13.0	1.53	14.33	16.67	238.67	131.27
BAU-2-3	10.7	1.57	13.00	18.67	243.00	133.65
BAU-2-4	10.7	1.47	14.00	15.67	219.67	120.82
BAU-3-3	12.7	1.50	15.00	15.67	235.33	129.43
BAU-3-4	11.0	1.50	13.00	15.00	195.33	107.43
BAU-4-1	11.7	1.47	14.67	15.00	220.00	121.00
BAU-5-1	10.7	1.60	15.00	15.67	234.67	129.07
BAU-5-2	13.3	1.33	14.00	15.00	210.33	115.68
CD (5%)	1.28	0.168	1.44	1.94	38.637	21.25
SE(d)	0.623	0.082	0.703	0.943	18.827	10.355
SE(m)	0.440	0.058	0.497	0.667	13.313	7.322
CV %	6.38	6.69	6.03	7.36	10.26	10.26

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Research Article

Investigation on guar gum and chitosan based polymer composite for oilfield water shut off fluid

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ABSTRACT

The present study highlights the performance of guar gum and chitosan based polymer composite (GG-CH-g-PAN/AA) as water shut off polymer solution for oilfield application. Study on salinity percentage, type of salts, pH and temperature for the salt present in formulation and salts contact with the polymer were investigated. The results of physical-chemicals parameters show that the composite polymer gave positive feedback as water shut off fluid at 60◦C and strength of fully developed polymer was obtained at 0.68 bar. The alteration in the appearance of GG-CH-g-PAN/AA from liquid gel to rigid polymer was achieved at the time difference between 120 minutes and 720 minutes, respectively. Expansion of polymer was noticed at high temperature due to excessive imbibition, meanwhile at low temperature for the same polymer showed shrinking behavior due to syneresis. Polymer GG-CH-g-PAN/AA exhibited 99.98% water permeability reduction and resulting to a significant characteristic as polymeric water shut off fluid.
Keywords: *Guar Gum, Chitosan, Water Shut Off Fluid, Water Control*

INTRODUCTION

Recovery of oil in petroleum industries plays essential roles to maintain oil production in petrochemical industries. Most field operators followed three stages of oil recovery, which are primary recovery, secondary recovery, and tertiary recovery. Primary recovery is commonly known as the natural force of water that helps to extrude oil out into channels bores. However, once the oil production is getting lesser, natural water force depletes. At a timeframe, the secondary recovery process has been introduced. Water injected to create a force for oil to elevate into bores channels. It is called water flooding process. However, for the time being, water and oil mixed aggregately and loss its heterogeneity. Water flooding process can cause damage via water oil hetero-aggregation, fractures or channels result from high water permeability and high water ratio to oil. Thus losses are common and gave negative impacts to oil producers.

At that juncture, tertiary recovery was introduced by using the injection technique to tackle small channels, fractures or pores with high water permeability. Usually, the type of polymers was selected to accomplish this recovery. Polymer injection technique provides a better solution to improve water-oil heterogeneity and minimize water production. The oil recovery injection method includes gel, particle, resin, or foam system were used worldwide. Among them, the polymer-based gel was the preferred method due to its effectiveness, promising result, flexible solidification time and controlled strength (Sydansk and Southwell, 1998). Emphasizing on polymer gelation system, the gel was engineered by the idea of grafting biopolymer with the hydrophobic polymer by using an oxidizing agent. Biopolymer such as guar gum, lignin, and cellulose have been used widely in oil gas industries for years (Place and Thomas, 2015). However, the field test indicated the degradation of macromolecules as results of the free radical attack (Mittal *et al.*, 2014). Biodegradation upon bacteria attack problems become the next concerned (Thombare *et al.*, 2016).

Therefore, industries are well known to dismiss or at least to avoid the addition of problems in polymer solution system. These are due to cost efficiency such as workforce, time and material consumption were premeditated. Guar gum is a long polysaccharide that widely used in oil and gas industries due to its potential as backbone polymer. As guar gum by itself cannot maintain long-term polymer durability, thus give an idea to combine guar gum to a synthetic polymer to obtain composite polymer for better stability, durability, molar change which could meet one's requirement (Kalia and Sabaa, 2013). It has been found that synthetic polymer-based gel has

potential to work at in low or high reservoir temperature. Guar gum grafted acrylonitrile (GG-g-PAN) has been synthesized by the various combination of polymerizations, for example okra grafted acrylonitrile (Mishra and Pal, 2007), chitosan grafted acrylonitrile (Singh *et al.*, 2004), guar gum grafted acrylic acid (Shruthi *et al.*, 2016) and guar gum grafted acrylonitrile (Thimma *et al.*, 2003).

In the present study, guar gum was blended with chitosan and combined with acrylonitrile and acrylic acid with the presence of oxidizing agent to improve the composite polymer to become water shut off solution. The composite polymer was improvised by the addition of acrylic acid as polymer filler and chitosan solution as time delay agent. The physical-chemical parameters, namely the effect of temperature, gel ageing effect, and salinity and pH on different composition, were investigated.

MATERIAL AND METHOD

Guar gum in the form of powder having the range of molecular weight of 50,000-8,000,000 was used as the water-soluble polymer for carrying experimental progress. Acrylonitrile (AN) and Cerium Ammonium Nitrate (CAN) were obtained from a Malaysian's manufacturer (RandM Chemical Sdn. Bhd.). Acrylic Acid, the polymer strengthener while Chitosan was received in flakes form. Hydrochloric acid which was also purchased from the same local supplier.

Polymer Preparation Method

Three types of stock solution were prepared prior to combination blends process. The stock solution for Guar Gum (GG) was obtained by dissolving GG powder with 1000ml the required solvent to get 1,000ppm. A stock solution of CAN was prepared for 100ml solution by dissolving CAN powder with 1M Nitric Acid to get 0.7M. The third stock solution was prepared by dissolving Chitosan (CH) flakes with 10ml of hydrochloric acid (HCl) and stirred to get 20,000ppm. CH concentrated, then, diluted to 1,000ppm concentration.

The samples was prepared under ambient atmosphere and temperature in 10 ml glass tube. In typical reaction, 5ml GG solution was measured. Then, 1ml CAN solution ware added at 0.7M concentration. Later, AN were added at 4v%. Later, 4v% of AA and CH added last with 20v%. Vigorous shaken blends then placed into oven at temperature ranging of 60◦C to 110◦C. Reaction growth is recorded and categorized into gelation time and rigid gel time. Table 1 gives the list of different polymer carrier solvent.

Gelation time test

Gelation time test was conducted by observing the formation of gelation from the mixed solution using coding system as shown in Table 2. The observation starts from the beginning with every 15 minutes interval until the polymer exceeds Code 1. The observation was done by tilting the sample bottle method to see polymer transition from liquid to solid. The point at which polymer appeared in gel form was known as Gelation Time (GT) and the time which polymer were hard n stayed upon tilting known as Rigid Gel Time (RGT). Two important code to be noticed which were the time of polymer gel started to develop (Code 1) and time when polymer gel was rigid and attached to bottles' wall (Code 3). The code is inspired by Syndansk's code which has been altered to suit the present polymer characteristic. The codes are as below:

Table 1: Concentration of salts and pH level

Sample	Solvent	Concentration	Sample	Solution	pH
1	DI water	-	8	NaOH	8
2	KCl	2v%	9	NaOH	10
3	KCl	6v%	10	NaOH	12
4	KCl	10v%	11	HCl	2
5	NaCl	2v%	12	HCl	4
6	NaCl	6v%	13	HCl	6
7	NaCl	10v%	14	Synthetic Seawater	-

Determination of Polymer Strength

Polymer strength (PS) is an important factor in developing the polymer gel. To understand the valid composition of polymer and its strength, the polymer was tested using the set-up as shown in Figure 2. This experimental set-up was meant to determine the performance of polymer against suction pressure. First polymer tear was recorded as polymer strength. This simple observation was also done by Dai *et al.*, (2014).

Table 2: Bulk gelation time coding system

Code	Bulk studies	Notation
0	Blank	Good injectivity
1	Cloudy, low viscosity	Filtration, high pressure
2	Cloudy, high viscosity	Filtration, high pressure
3	Rigid gel	Complete blocking

Polymer growth confirmation by conductivity test

Growth of composite polymer was studied to by recording the time of polymer transition from liquid solution to solid gel. This confirmation test was carried by using conductivity test by using HI9829-03042 Multi-parameter from Hanna Instruments. The idea of this test is to measure free flow charges usually in water as medium and also other dissolved chemicals components. The conductivity of polymer was measured from liquid solution into harden polymer and were observed for 24 hours.

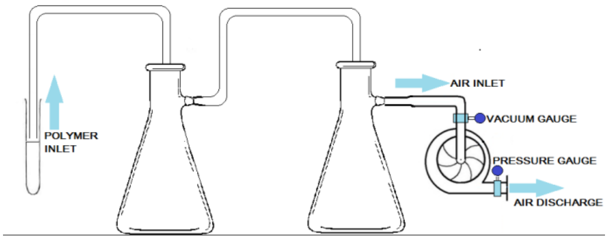

Figure 2: Diagram of polymer strength evaluation test (Dai et. al., 2014)

Viscosity test

Polymer viscosity was tested by using Brookfield Engineering Programmable LVDV II+ Viscometer. This polymer is tested to confirm gelation time by inspired Syndansk's tilting method. The polymer solution was placed in the water jacket at the temperature of 60◦C and viscosity of the polymer was recorded for every 10 minutes time interval. The recorded data continued until polymer reaching Code 1. Further then Code 1, viscosity is not applicable due to water separation from the polymer at the time of polymerization progress.

Rheology test

The rheological behaviour of polymer has been analysed by using HR-2 Discovery Hybrid Rheometer. Sinusoidal shear stress was measured to monitor the performance of cured polymer and gel effect without affecting the 3D structure of the gel. The cured polymer was tested to determine the characteristic of synthesized polymer at 60◦C.

Polymer expansion evaluation study

The cured polymer then will undergo expansion test to evaluate the effect of shrinkage or expanding polymer by time being under given condition such as salts contact, temperature and acidic or alkalic contact. These cured polymers were set in its present condition and observed until 45 days. Data was collected by measuring the length of polymer either loss or gain. These data are presented in percentage.

Permeability Study

Permeability reduction is the aimed results for confirming the reliability of water shut off fluid. Therefore, the polymer was designed for water permeability reduction. Figure 3 illustrates the diagram of core flooding rig for permeability study. The procedure started with water flooding through Berea sandstone core with assigned pressure condition until water discharge was stable. The polymer solution was then injected by same pressure condition with 10 pore volume (PV). Later on, the polymer saturated core was placed in the oven at 60◦C temperature for 72 hours for the purpose of polymer curing. Then, cured polymer core was then being flowed with water again from opposite core direction at same pressure condition. Pressure depletion was recorded by 24 hours gap until there was a noticeable pressure drop.

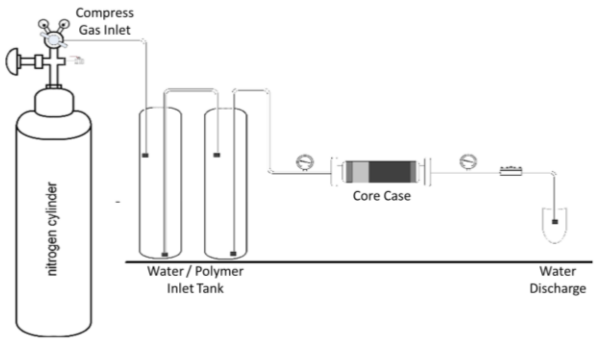

Figure 3: Core flooding rig

RESULT AND DISCUSSION

Polymer synthesized with the present of different salts

The effects of synthesized polymers in different solvent were recorded on notation of gelation time (GT), rigid get time (RGT) and polymer strength (PS). Table 3 shows the results of polymer gelation time, rigid gel time and polymer strength in different solvent at 60◦C.

Table 3: Polymer Gelation and Polymer Strength

Sample	Solvent Composition	Gelation Time (m)	Rigid Gel Time (m)	Polymer Strength (bar)
1	Distilled water	120	720	0.68
2	2% KCl solution	90	3660	0.52
3	6% KCl solution	150	3690	0.50
4	10% KCl solution	600	3760	0.50
5	2% NaCl solution	90	600	0.68
6	6% NaCl solution	105	630	0.68
7	10% NaCl solution	120	700	0.68
8	pH 8, NaOH solution	120	600	0.68
9	pH 10, NaOH solution	150	600	0.65
10	pH 12, NaOH solution	3760	4000	0.06
11	pH 2, HCl solution	180	600	0.68
12	pH 4, HCl solution	210	700	0.68
13	pH 6, HCl solution	230	1880	0.48
14	Synthetic Seawater	120	1880	0.58

Different behaviour of polymer in the presence of other chemical compounds during blending was observed. Sample 1 was taken as blank sample for the rest of solvent composition. The desired GT, RGT and PS for this experiment were 120 minutes, 720 minutes and 0.68 bar respectively which similar to Sample 1. From Table 3, it was observed that, the

presence of NaCl compound, low alkalic solution and high acidic solution did not weaken the composite polymer strength. However, the period of achieving the desired GT and RGT were shifted to be faster or slower depending on the ionic interruption during polymerization. In the presence of KCl compound, high alkalic solution and low acidic solution, the period taken and polymer strength were interrupted. From these results, the present of other chemical compounds had to be understood in order to adjust the period and pre-treatment approaches during polymer injection into water streaks wellbore.

Polymer growth confirmation by conductivity test

Synthesized guar gum polymer was tested to understand the performance and period taken for polymerization. The polymerization time is a crucial factor in developing polymeric water shut off fluid. In this work, conductivity test had been performed to investigate the growth of synthesized polymer. The decrease in charges indicated polymer solution turned into solid by time. Figure 4 shows the effect of polymer conductivity with time. The results can generally be divided into four section. Section 1 shows increasing charges of conductivity which may indicate the initiation of polymerization sites by the presence of oxidant. Line 1 was the gelation time indicated as Code 1 (Table 4), where first gel formation appeared.

Section 2 was indicated by the fluctuation of conductivity reading. The fluctuation might cause from the formation of gel polymer and its reaction. Line 2 is the end point of polymer fluctuation.

Section 3 is illustrated by stable decrement in conductivity values. This indicated polymerization process was final and water absorption process took place. At this time water absorption may cause water charges to be lesser and trapped inside polymer structure. Line 3 indicates the RGT from observation which polymer hardened.

Section 4 showed the conductivity value uniformly drops and was continued for 24 hours. These free charges expected to increase and fluctuate in a time range then decrease due to initiation, propagation and termination step in polymerization, and absorption of water charges by polymer charges which turn into the solid gel.

Viscosity of composite polymer

Figure 5 showed viscosity progression during polymerization of composite polymer. Composite polymer showed polymer growth was insignificant in term of viscosity increment at Code 1 until 120 minutes to 150 minutes. Then, after 150 minutes, polymer growth were noticeable due to the increase in viscosity. It was noticed that harden polymer was measured at 120 cP. The notation for polymer were tabulated in Table 4.

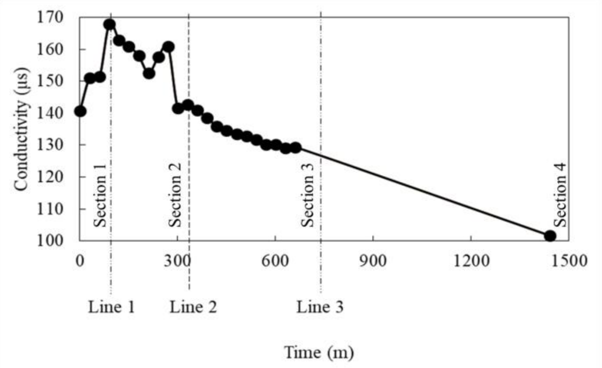

Figure 4: Effect of polymer conductivity with time

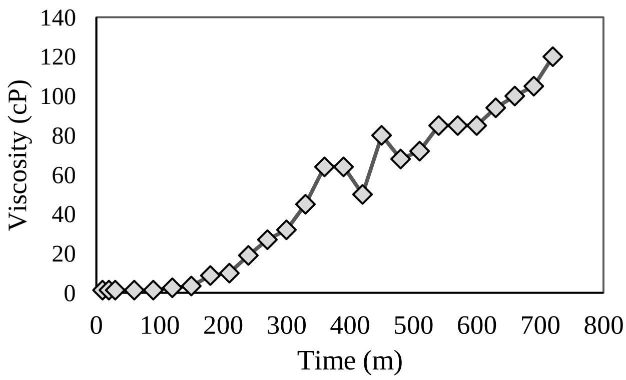

Figure 5: Viscosity pattern of grafted guar gum by time

Rheology characteristic of the composite polymer

Rheology study of the polymer is an important factor to engineered the designed polymer. This is to ensure polymer is strong enough to hold its network and its shape to withstand robust flow (high stress) condition inside the wellbore. Storage and loss modulus are the stress response for a visco-elastic fluid in oscillatory shear. Usually, storage modulus (G') is indicating sturdiness of polymer to overcome torque and maintaining its original shape, and loss modulus (G”) is the viscous respond which indicates the flowing behaviour of polymer. Figure 6 shows the G’ and G” of synthesized polymer at 60◦C. The result reveals that the G’ of composite polymer is higher compare to G”. This indicated that the synthesized polymer gave elastic behaviour rather than viscous behaviour. By increasing angular frequency, polymer elasticity increased. This findings is good since the composite polymer able to retain its structure at higher shear force.

These visco-elastic property were determined by calculating applied strain, δ, of $\tan^{-1}$ (loss modulus/elastic modulus). The range of visco-elastic properties was between 0◦ until 90◦, where 0◦ was an ideal elastic solid and 90◦ is an ideal Newtonian fluid. The reading of CHS/GG-g-PAN/AA was around 0.3. the stability of composite polymer were aligned with findings from few researchers such, the acrylic acid (AA) and Chitosan (CH) which act as filler (Jamaludin and Hashim, 2011) and time delay agent (Zheng *et al.*, 2016), which proven aid of these two

polymers may strengthen the composite polymer (Kundu *et al.*, 2015) with time targeting polymerization process.

Table 4: Bulk gelation, notation and the correlation with viscosity

Code	Bulk studies	Notation	Viscosity Build up (cP)
0	Blank	Good injectivity	1
1	Cloudy , low viscosity	Filtration, low pressure	2.56
2	Cloudy, high viscosity	Filtration, high pressure	64
3	Rigid gel	Complete blocking	120

These visco-elastic property were determined by calculating applied strain, δ, of $\tan^{-1}$ (loss modulus/elastic modulus). The range of visco-elastic properties was between 0◦ until 90◦, where 0◦ was an ideal elastic solid and 90◦ is an ideal Newtonian fluid. The reading of CHS/GG-g-PAN/AA was around 0.3. the stability of composite polymer were aligned with findings from few researchers such, the acrylic acid (AA) and Chitosan (CH) which act as filler (Jamaludin and Hashim, 2011) and time delay agent (Zheng *et al.*, 2016), which proven aid of these two polymers may strengthen the composite polymer (Kundu *et al.*, 2015) with time targeting polymerization process.

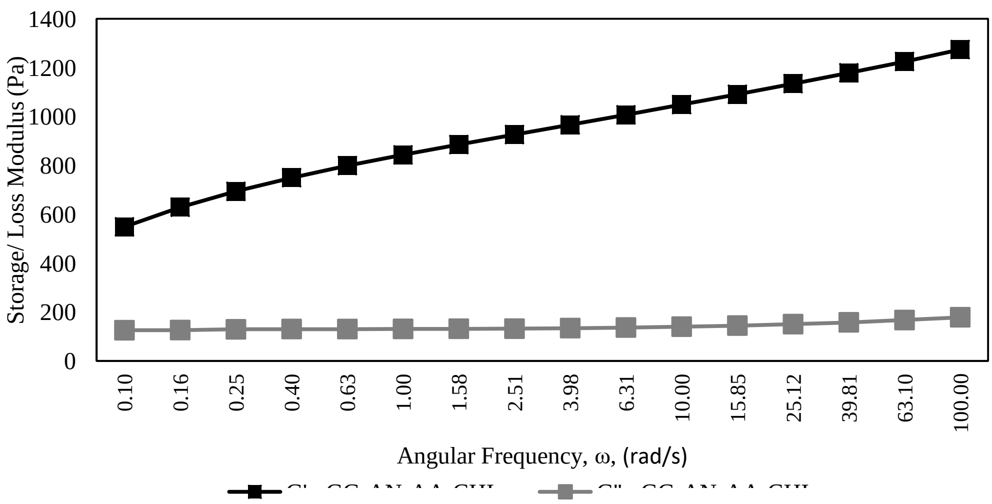

Figure 6: Storage modulus and Loss modulus of GG-CH-g-PAN/AA

Expansion test of polymer in contact with different salts and pH

Expansion evaluation is a test to study the ability of a polymer to withstand its structure with different salts contact and pH imbalance once it cured. This test is aimed to prove that GG-CH-g-PAN/AA can be a good polymeric water shut off fluid due to its stability toward external factors. Effect of salts was investigated to understand the reaction of polymer towards the presence of salt solution in a carrier medium. Two different salts solutions were set in contact with the cured polymer for 180 days. The negative value in percentage indicating shrinkages of the polymer by time and the positive value indicating expansion of polymer by time. It was known that the ideal efficient polymer, was the one that inert to external factors. However, this was very hard to achieve. Due to the molarity of water inside polymer, there will be some changes that are preferable to avoid.

Figure 7 shows the results of expansion test for composite polymer in contact with different KCl solution concentrations at different temperature for 180 days. From the results, GG-CH-g-PAN/AA has experienced shrinkages at 60◦C much obvious for all KCl concentration compared to higher temperature. For 85◦C, there were slight decrease in shrinkage percentage and noticeable expansion at higher KCl concentrations. However, at 110◦C, the polymer were experienced imbibition which polymer tend to expand from initial length for all condition.

Imbibition factor does give some pros and cons for polymeric water shut off fluid. It can give good impact by sealing polymer pores much deeper thus hinder water movement affecting areal sweep. However, in this current experiment, viscous respond were noticed at high temperature. This can cause the polymer to loosen its visco-elastic characteristic due to its excessive expansion thus loosen its 3D structure which later, water may sweep the polymer bond by continuous water flooding. Thus, this can cause thermal polymer degradation and polymeric water shut off are ineffective anymore.

Figure 8 shows the expansion effects when in contact with different NaCl solution concentrations at different temperature. It was noticed that when in

contact with NaCl, composite polymer gave less polymer interruption compared to it when in contact with KCl. At 60◦C and 85◦C, composite polymer experienced only shrinkage rather than imbibe. However, at 110◦C, when in contact with water and 2% NaCl the composite polymer showed imbibition effect. The presence of NaCl solution was noticed to curb excessive imbibition of composite polymer.

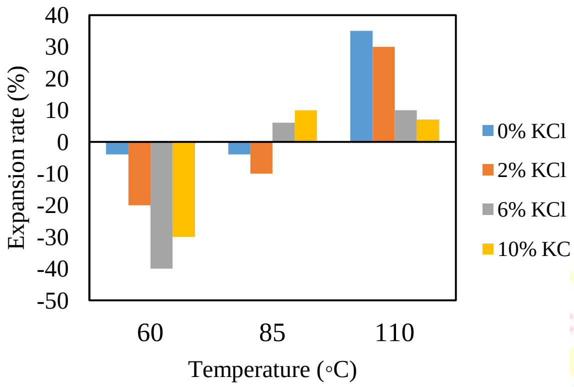

Figure 7: Expansion test of composite polymer in contact with different KCl solution concentrations at different temperature for 180 days.

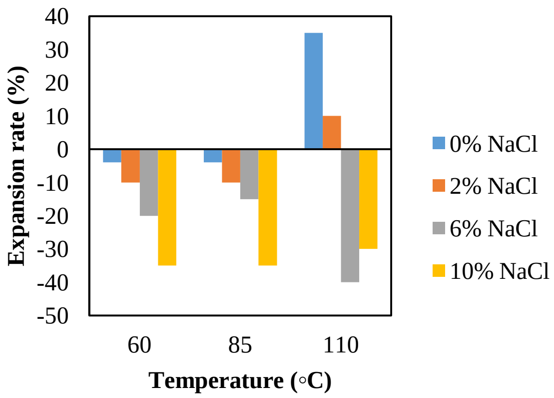

Figure 8: Expansion test of composite polymer in contact with different NaCl content at different temperature for 180 days.

The effect of pH was investigated to understand the polymer reaction toward different pH level when in contact with the composite polymer. Figure 9 shows the results of expansion test for GG-CH-g-PAN/AA at different pH and temperature. Shrinkages were unnoticeable at low temperature, 60◦C and medium temperature, 85◦C for all pH. However, at high temperature, 110◦C, composite polymer experienced excessive expansion at all pH. The imbibition process was obvious which can be considered polymer lost its shape. Water sweeping may cause the polymer to degrade further by the presence of different pH. At high temperature, 110◦C, this composite polymer was found stable in the acidic condition which was around pH 2 compare to the one in contact with water. It was noticed that, high acidity solution can curb polymer to excess imbibe by the hindrance of H^+ ions from water ions attach to polymer sites. This was also lead to temperature effects on polymer were curb due to strong ionic hindrance.

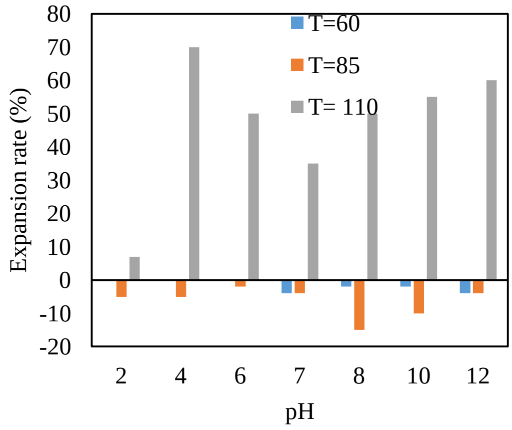

Figure 9: Expansion test for GG-CH-g-PAN/AA at different pH and temperature.

Permeability Study

Permeability study of GG-CH-g-PAN as water shut off fluid was investigated using the same amount of GG, AN, AA, CHS and CAN as the previous tests. The experimental investigation was presented in Table 5. The initial permeability was 9.3107 Darcy. After flooding with 2% KCl brine for 4 hours at constant pressure, 20 psi until brine discharge was stable, composite polymer solution was injected with 10PV for 2hours with the contact pressure of 20 psi to ensure fully saturated core with the polymer solution. Next, the saturated polymer was cured for 3 days to ensure full polymerization were completed. After in situ gelation, brine was flooded backward at 20 psi with 10PV as well. The initial pressure is set at 20 psi, and further noticeable pressure drop showed.

Table 5: Effect of permeability on Berea sandstone core

Porosity	28%
Initial permeability	9.3107 Darcy
Post gelation permeability	0.0019 Darcy
Permeability reduction	99.98
Resistance factor	29.5
Residual resistance factor	0.0075

It was observed that permeability of polymer saturated core was reduced to 0.0091 Darcy, with the percentage of permeability reduction of 99.98% and the resistance factor was about 29.5 was reduced to 0.0075. There were huge different in permeability by the present of polymer, indicated that GG-CH-g-PAN/AA composite was an excellent candidate to be as polymeric water shut off fluid. The ability and stability of polymer as water shut off fluid were

proven to be able to seal water streaks and pores which can be applied in oilfield industries (Singh and Mahto, 2016).

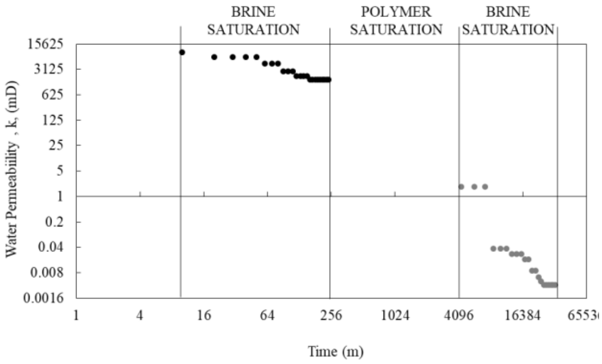

Figure 10: Permeability reduction pattern of GG-CH-g-PAN/AA by time

The experimental works performed for GG-CH-g-PAN/AA composite gave a positive result and proved the designed composite is suitable to be water shut off fluid at the temperature of 60◦C. The polymer strength of effectively well-developed composite was at 0.68 bar for GG-CH-g-PAN/AA along with the optimal gelation time (GT) at 120 minutes and the rigid gel time (RGT) was at 720 minutes. For the syneresis effect of the composite polymer, synthesized GG-CH-g-PAN/AA did not experience much syneresis or further imbibition effect when in contact with different salts solutions at different concentration. However, at high temperature, polymer composite gave less syneresis impact compared to the lower temperature. Furthermore, synthesized polymer composite gave effects due to the imbalance of pH value. Expansion of polymer were noticed at high temperature due to further imbibition while, at low temperature the composite polymer experienced shrinkage due to syneresis. Effect of polymer expansion was more obvious due to pH imbalance compared to salts solution concentration at high temperature. The composite polymer showed almost 100% permeability reduction. Thus, this GG-CH based composite polymer could be a good candidate as polymeric water shut off fluid.

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Research Article

Response of wheat yield and its components to zinc and iron application under different levels of nitrogen

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ABSTRACT

To evaluate the effect of nitrogen, zinc and iron as soil application on yield and yield component of wheat, the present study was conducted at Agricultural and Experimental Research Station at Giza, Faculty of Agriculture Cairo University, Egypt during 2015/2016 and 2016/2017 seasons. The experimental design was split-plot in randomized complete block design with three replications. Results showed that positive significant effect on plant height, number of spike/m^2, spike length; number of grain per spike, grain yield per unit area in both seasons and grain protein content in one season were achieved by application of N and the micronutrients. Whoever, the highest significant in the above mentioned characters was obtained either by application the highest N levels (100kg N /fed.) or in addition to mixture of Zn and Fe. The interaction between the studied factors had significant effect on plant height and grain yield in both seasons as well as on grain protein content in the second season, where the highest values of these parameters were recorded by application of 100kg N/fed., Zn and Fe in mixture.
Keywords: *Wheat yield, nitrogen, zinc and iron*.

INTRODUCTION

Wheat (*Triticun aestivum* L.) is the most important cereal crop in the world, because it is now the important grain crop in international commerce and it is excellent storing and shipping quality make it available to people almost everywhere. In Egypt, the total production of the wheat is still far below the annual demand. This gap can be filled by increasing wheat area especially in the reclaimed lands, increasing the productivity at the plant area and decreasing the losses in production and consumption., Consequently, Increasing wheat production under Egyptian conditions is a major concern of the Agronomist.

Balanced nutrition of the plant is one of the main factors that affects the yield quality of plant. Nitrogen fertilization is an important factor in front of wheat agronomists for achieving yield targets. Several investigator found positive response of wheat to nitrogen fertilization (Anssari *et al.* , 2010; Wahid, 2013; Saraka *et al.*, 2014). Another essential nutrients are Zn and Fe. Zn plays a special role in synthesizing protein, RNA and DNA, chlorophyll synthesis, thylakoid synthesis and chloroplast development. Fe play an active role in several enzymatic activates of photosynthesis as well respiration (Ali *et al.*, 2012 and Mosoud *et al.*, 2012). Moreover, Zn and Fe take over different roles in crop such as a formation partitioning and utilization of photosynthesis assimilates. Several investigators recorded positive response of wheat to Zn and Fe fertilization (Nasiri *et al.*, 2010; Nadim *et al.*, 2011; Habib, 2012; Inayat *et al.*, 2014; Ghafoor *et al.*, 2015 and Zain *et al.*, 2015). Consequently, the present study aimed to investigated the response of wheat yield and its components to Zn and Fe application under different N levels.

MATEREALS AND METHODS

Grain yield and its components of wheat (*Triticum aestivum* L.) cv. Giza 168 as affected by soil application of Zn Fe and Zn + Fe under tree N levels, i.e. 60, 80 and 100 kg N/fed. (one Fedden = 4200m^2) were studied. Experiments were conducted at Agricultural and Experimental Research Station at Giza, Faculty of Agriculture, Cairo University, Egypt during two successive winter seasons 2015/2016 and 2016/2017. As mean of the two seasons, the soil type of the experiments was loamy in texture where the soil fertility status cleared that soil was low in N, Zn and Fe (available N, Zn and Fe were 30.3 - 32.6, 10.02 – 10.11 and 2.01 - 2.03 ppm, respectively). The experimental design was split-plot in randomized complete block

design in three replications. Nitrogen fertilizer levels occupied the main plots and micronutrients were allocated in sub-plots.

The preceding crop was corn in both seasons. Grains were sown on the third week of November in both seasons. Nitrogen fertilizer in the form of urea 46%N was added in a split application, one half was applied at sowing time and the rest before the first irrigation (21 days after planting). Zn and Fe in sulfate form at the rate of 20 kg/fed. were added to the soil before the first irrigation. Zn and Fe were added either individually or in mixture. At harvest time, wheat plants were collected from each sub-plot and plant height, number of spike/m^2 , spike length, number of grains/spike, 1000-grain weight, grain yield per unit area and grain protein content were estimated. All the data collected during the both seasons were subjected to statistical software package *MSTAT*-C (Michigan Stat University,1190). Least Significant Differences Test (L. S. D.) at 0.05 probability was used to test significances among mean values of each treatment (Steel and Torrie, 1997).

RESULS AND DISSCTIONS

Effect of nitrogen fertilizer levels

Increasing N levels up to 100 kg N/fed. caused a significant and gradually increase in plant height, number of spikes/m^2 , spike length, number of grain /spike and grain yield/fed. in both seasons and grain protein content in the second one (Table 1 and 2). As an average of two season, increasing N levels up to 100 kg N/fed. caused an obvious increase in the above mentioned characters by 1.3, 4.4, 8.1, 7.1, 24.6 and 9.1 % over the application of the lower nitrogen levels (60 and 80 kg N/fed.). Moreover, grain yield response per kg of N was calculated as 15 and 20 kg of grains for 80 and 100 kg N/fed., respectively. These results expected that nitrogen is one of the most important component of cytoplasm, nucleic acid and chlorophyll. Therefore, as the level of nitrogen increased rapid multiplication of cells occurs which in turn enhanced the amount of metabolist necessary for building plant organs. These results are in harmony with these recording by Anssari *et al.*(2010), Gheith *et al.* (2013), Guo *et al.* (2013), Wahid (2013) and Szmigiel *et al.* (2014) who reported that grain yield per unit area was increased significantly with increasing N levels. Moreover, Sarka *et al.* (2014) found that protein content in grains increased significantly was increased N levels.

Effect of Zn and Fe fertilizer

Results presented in Table (3 & 4) showed that plant height (in first season), number of spikes/m^2 and grain yield /fed. in both seasons were significantly affected by application of Zn and Fe. On the contrary, this effect was not true regarding spike length, number of grains /spike, grain weight/spike, thousand grain weight and grain protein content in both seasons. In general, application of Zn + Fe combination treatment produced the highest values for the studied characters, while the lowest values were recording with application of Fe alone in both seasons. The previous finding may be dye to that Zn and Fe, in general, are required to a healthy growth and life cycle completion (Ali *et al.*, 2012).

Table 1: Yield and its components as affected by nitrogen levels in 2014/2015 season.

Yield and its components	N levels (kg/fed.) 60	80	100	F	L.S.D.
Plant height (cm)	110.3	110.9	112.6	*	1.5
Number of spikes/m^2	440.6	445.3	468.2	*	14.3
Spike length (cm)	10.1	10.3	10.8	*	0.2
Number of grains/spike	51.7	53.9	56.3	*	2.2
Weight of grains/spike(g)	2.5	2.6	2.8	ns	-
1000-grain weight (g)	42.6	42.9	43.3	ns	-
Grain yield (t/fed.)	2.7	3.0	3.4	*	0.2
Grain protein content (%)	14.2	14.3	14.5	ns	-

* = Significant and ns = Not significant at 0.05 level.

Table 2: Yield and its components as affected by nitrogen levels in 2015/2016 season.

Yield and its components	N levels (kg/fed.) 60	80	100	F	L.S.D.
Plant height (cm)	114.2	114.5	114.8	*	1.2
Number of spikes/m^2	439.3	440.1	441.8	*	0.4
Spike length (cm)	9.8	10.3	10.7	*	0.3
Number of grains/spike	57.5	60.5	60.8	*	3.0
Weight of grains/spike(g)	2.4	2.5	2.6	ns	-
1000-grain weight (g)	42.7	42.8	44.1	ns	-
Grain yield (t/fed.)	3.0	3.3	3.7	*	0.3
Grain protein content (%)	12.1	14.5	14.2	*	0.4

* = Significant and ns = Not significant at 0.05 level.

Its plays a role in many function in plant growth and development. This function includes chlorophyll synthesis, enzymatic activities of photosynthesis, synthesizing protein, RNA and DNA (Ali *et al.* 2012 and Mosoud *et al.*,2012). The present results are in harmony with those obtained by many researchers of them Nasiri *et al.* (2010), Yassen *et al.* (2010), Nadim *et al.* (2011), Bameri *et al.* (2012), Habib *et al.* (2012), Khan *et al.* (2012), Inayat *et al.* (2014), Ghafoor *et al.* (2015) and Zain *et al.* (2015) who reported that

application of micronutrient to wheat caused an increase in either grain yield or yield components.

Effect of the interaction

Results in Table (5) indicated that the interaction between the two studied factors had significant effect on plant height and grain yield pre unit area in both seasons and grain protein content in the second season. The tallest plants (114.6 and 115.5 cm) and maximum grain yield (3.9 and 3.6 t/fed.) in both seasons, respectively recorded by application of the highest N level (100 kg N/fed.) and mixture of Zn + Fe treatment. As regarding the grain protein content, the highest value (14.6%) was produced under the same treatment in the second season.

The results of this study showed that under the condition of this experiment, there was positive significant effect on grain yield and its related characters were achieved by application of 100 kg N/fed. and mixture of Zn + Fe. It is evident also application of 100 kg N/fed. with mixture of Zn + Fe was the best treatment recorded the highest values of all studied character comparing with other treatments.

Table 3: Yield and its components as affected by different micronutrients in 2014/2015 season.

Yield and its components	Micronutrients Zn	Fe	Zn + Fe	F	L.S.D.
Plant height (cm)	112.9	106.9	114.5	*	2.1
Number of spikes/m^2	448.3	440.2	458.3	*	7.9
Spike length (cm)	10.3	10.1	10.5	ns	-
Number of grains/spike	50.6	51.2	52.3	ns	-
Weight of grains/spike(g)	1.9	2.2	2.3	ns	-
1000-grain weight (g)	43.7	43.2	44.5	ns	-
Grain yield (t/fed.)	2.4	2.2	2.6	*	0.2
Grain protein content (%)	14.0	14.1	14.3	ns	-

* = Significant and ns = Not significant at 0.05 level.

Table 4: Yield and its components as affected by different micronutrients in 2015/2016 season.

Yield and its components	Micronutrients Zn	Fe	Zn + Fe	F	L.S.D.
Plant height (cm)	114.5	114.2	114.7	ns	-
Number of spikes/m^2	444.0	450.1	453.2	*	2.8
Spike length (cm)	10.1	10.3	10.4	ns	-
Number of grains/spike	49.5	50.3	51.6	ns	-
Weight of grains/spike(g)	2.2	2.4	2.5	ns	-
1000-grain weight (g)	41.2	41.6	42.5	ns	-
Grain yield (t/fed.)	3.3	3.2	3.6	*	0.3
Grain protein content (%)	12.8	12.3	13.5	ns	-

* = Significant and ns = Not significant at 0.05 level

Table 5: Effect of interaction on plant height (cm), grain yield (t/fed.) and grain protein content(%) .

N levels (kg/fed.)	Micro-nutrients	Plant height 1st season	Plant height 2nd season	Grain yield 1st season	Grain yield 2nd season	Grain protein 2nd season
60	Zn	113.9	114.5	3.0	3.1	11.5
	Fe	102.6	113.9	2.8	3.0	12.1
	Zn+Fe	114.5	114.3	3.3	3.1	12.7
80	Zn	112.4	114.5	3.3	3.2	13.0
	Fe	109.5	114.3	3.2	3.1	12.3
	Zn+Fe	114.5	114.8	3.5	3.4	13.2
100	Zn	112.8	114.6	3.5	3.5	14.0
	Fe	108.3	114.2	3.4	3.1	12.6
	Zn+Fe	114.6	115.5	3.9	3.6	14.6
F- test		*	*	*	*	*
L.S.D. 0.05 %		2.5	0.5	0.4	0.3	1.5

* = Significant at 0.05 level

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Research Article

Soil nutrient status under different agro-climatic zones of Jammu region, India

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ABSTRACT
In the North Western Himalayas, particularly Jammu region, where 85% of people depend on agriculture and allied sectors, 70% of agriculture is rain-fed. Various factors, especially land use pattern and variations in climatic conditions affect the soil fertility and nutrient contents. However, information on essential nutrients in the soil across the region is meager. An attempt has been made to study the soil nutrient status under different agro-climatic zones of Jammu region. Seven hundred seventy surface soil samples (0-15 cm) from sub-tropical, intermediate and temperate zones of Jammu region were collected and analyzed for soil texture, pH, electrical conductivity (EC), organic carbon (OC), $CaCO_3$, CEC, available macro nutrients (N, P, K, S) and micronutrients (Fe, Cu, Zn, Mn). The results indicated large variation within the soils of each zone. The amount of all the available nutrients was more in the soils of temperate zone than those of other zones. The soils of sub-tropical zones were low in available N, P, S and Zn and to some extent in K. Organic matter content, clay and silt content of the soil *vis-à-vis* cation exchange capacity were found to be the main factors controlling the available nutrient content of the studied soils.
Keywords: *Soil fertility, macro and micronutrients status, agro-climatic zones, Jammu region.*

INTRODUCTION
Agriculture productivity is greatly determined by quality of the soil, especially availability of the nutrients. It plays key role in economy and overall social well-being of India (Mall *et al.*, 2006). The population of our country is increasing at a rapid rate, whereas the land and water resources for agriculture are diminishing continuously. Mountain ecosystems are changing rapidly. They are susceptible to accelerated soil erosion, landslides and rapid loss of habitat and genetic diversity (Sanjay-Swami, 2019). The rain-fed regions are also on verge of degradation and have low cropping intensity, low organic matter status, low microbial activity, low fertility and poor soil physical health. Yield efficiency of soil can be based on availability of nutrients in the soil and categorizing soil accordingly is important for appropriately planning agriculture (Gregorich and Carter, 1997). Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have a high degree of spatial variability. An inventory of the available nutrient status of soils helps in demarcating areas where application of a particular nutrient is needed for profitable crop production. The available nutrient status of the soils of some agro-climatic zones of Jammu region has been reported (Gupta and Verma *et al.*, 1975). However, soils vary in their physico-chemical characteristics even within the same contiguous area which markedly affect the availability of nutrients. Three agro-climatic zones have recently been established in Jammu region (Rana *et al*., 2000). Therefore, an attempt has been made to find out the effect of important soils characteristics on the availability of nutrients in these agro-climatic zone *viz.* sub-tropical, intermediate and temperate zones to monitor the extent of nutrient deficiencies in soils of the studied area.

MATERIALS AND METHODS
Surface soil samples (0-15 cm) totaling 770 were collected from three agro-climatic zones *viz.* sub-

tropical, intermediate and temperate zones of Jammu region. The soil samples were air dried, ground in a wooden pestle and mortar and sieved through 2 mm plastic sieve. The pH and electrical conductivity (EC) of the soil samples were measured in 1:2 soil : water suspension. The organic carbon (OC), $CaCO_3$, available N, Olsen's P, available K was estimated according to standard procedures (Black, 1965). Texture was estimated by hydrometer method. The available Fe, Cu, Zn and Mn were estimated by DTPA method (Lindsay and Norvell, 1978). The contents of Fe, Cu, Zn and Mn in soil extracts were determined by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Soil fertility is a key component in its productivity and quality (Rao and Reddy, 2005). Despite agriculture being a prime component in Indian economy, regional database on essential nutrients in most of the areas in the country is incomplete. Some basic information on morphological and physico-chemical properties of the soils of various agro-climatic zones of Jammu region has been given by Rana *et al*., (2000). However, brief descriptions of the physico-chemical properties of the three agro-climatic zones under study are given below:

Sub-tropical zone:

Soils are coarse loamy to fine loamy and mostly non-calcareous, imperfectly drained mostly from Ravi-Tawi command area. The soils are neutral to alkaline in reaction. The pH and EC of these soils ranged from 7.0 to 9.4 and 0.03 to 0.62 dSm^{-1} respectively. The calcium carbonate content varied from 0.09 to 3.70 percent with a mean value of 0.65 percent (Table 1). The mean organic carbon content of these soils was 0.45 per cent with an overall range from 0.10 to 1.27 per cent. The CEC varied from 7.80 to 10.86 C mol (P^+) kg^{-1} with a mean value of 9.25 C mol (P^+) kg^{-1}.

Intermediate zone:

The soils are non-calcareous, perfectly drained with *udic* to *ustic* moisture regimes. Soils of this agro-climatic zone were sandy loam to loam in texture; pH ranged between 6.5 and 8.4 with a mean value of 6.5. Electrical conductivity varied from 0.03 to 0.36 dSm^{-1} with an average value of 0.12 dSm^{-1}. The mean OC and $CaCO_3$ were 0.85 and 0.15 per cent with their respective overall range of 0.37 to 1.72 and 0.0 to 2.80 per cent, respectively. The CEC varied from 8.02 to 13.80 C mol (P^+) kg^{-1} with a mean value of 11.62 C mol (P^+) kg^{-1} (Table 1).

Temperate zone:

These soils are shallow to deep, some what excessively to excessively drained mostly loamy-skeletal. They are most non-calcareous slightly acidic to neutral in reaction with pH varying from 4.5 to 7.8 with a mean of 6.5. The variation in OC content was from 0.90 to 3.30 per cent with an average value of 1.09. The $CaCo_3$ content was generally low and ranged between 0.00 to 1.15 content with a mean value of 0.09 per cent. There were small variation in CEC and it ranged from 13.98 to 14.93 C mol (P^+) kg^{-1} with a mean value of 14.42 C mol (P^+) kg^{-1} (Table 1)

Macronutrient status

Nitrogen:

The available N content of the three agro-climatic soils varied from 180 to 460 kg ha^{-1}. In the sub-tropical zone soils, it varied from low to medium with mean value of 267 kg ha^{-1} and most of these soils (65%) were low in available N status. In intermediate zone soils, 62% of the soils were medium and 38% were low in available N with a range of 170-384 kg ha^{-1}. All the soils of temperate zone were medium in available N and it ranged from 332-425 kg ha^{-1} with a mean value of 379 kg ha^{-1} (Table 2). The N deficiency is more in sub-tropical zone soils due to low organic carbon content of these soils. Higher vegetation content in the area favors higher degradation rate and removal of organic matter leading to nitrogen deficiency. The variation in N content may be related to soil management practices, application of FYM and fertilizer to previous crops. Nagaraj (2001) observed a similar trend of nutrient status in black soils of North Karnataka. For obtaining potential crop yield and full benefits from costly inputs of fertilizer etc., it is imperative to mitigate N deficiency from these soils with FYM and nitrogen application.

Phosphorus:

The available P content in all the soils studied in the present study was in the medium range. It varied from 4.2 to 18.2, 12.2 to 20.7 and 16.3 to 19.2 kg P ha^{-1} in sub-tropical, intermediate and temperate zone soils, respectively (Table 2). Available P deficiency was noticed in some sub-tropical zone soils and this could be due to intensive cropping pattern in these soils than the soils of other two zones. Similar status of available phosphorus was obtained by Jatav *et al.*, (2011) and was due to the lesser use of super phosphate by the farmers who prefer FYM at a rate depending upon its availability at the site.

Potassium:

The available K content in the sub-tropical soils varied from low to medium category, the range being 105-210 kg ha^{-1} with a mean value of 151 kg ha^{-1} (Table 2). All the soils from the intermediate zone and temperate zone were found to be medium to high in available potassium status. Earlier analysis reports of early eighties indicated that the available K status of sub-tropical zone soils varied from medium to high status and this trend is now decreasing due to intensive cropping in this zone. About 15% soil samples of this zone were deficient in available K (less than 110 kg ha^{-1}) and the potential deficient areas were Dehiyan, Samba, Raya, Dyalachak and Lakhanpur in sub-tropical zone. These soils need immediate application of K for sustainability as well as for obtaining optimum yields.

Table 1: Physico-chemical characteristics of the soils of Jammu region

Agro-climatic zone	Elevation (m)	No. of soil samples	Texture	pH		EC (dSm^{-1})		OC (%)		$CaCO_3$ (%)		CEC (C mol (P^+) kg	
				Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Sub-tropical	215-360	480	Sandy loam to silty clay	7.0-9.4	8.1	0.03-0.62	0.27	0.10-1.27	0.45	0.09-3.70	0.65	7.80 - 10.86	9.25
Intermediate	360-1000	220	-do-	6.5-8.4	6.7	0.03-0.36	0.12	0.37-1.72	0.85	0.00-280	0.15	8.02-13.80	11.62
Temperate	1000-2500	70	-do-	4.5-7.8	6.5	0.10-0.18	0.13	0.90-3.30	1.09	0.00-1.15	0.09	13.98-14.93	14.42

Table 2: Available macronutrient status of the soils of Jammu region

Agro-climatic zone	Elevation (m)	No. of soil samples	Macro-nutrients (kg ha^{-1})						Sulphur (mg kg^{-1})	
			N		P		K		S	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range
Sub-tropical	215-360	480	267	180-460	12.3	4.2-18.2	151	105-210	20.4	8.0-34.3
Intermediate	360-1000	220	295	170-384	16.3	12.2-20.7	253	143-293	23.8	10.0-35.7
Temperate	1000-2500	70	379	332-425	17.5	16.3-19.2	343	291-419	29.6	9.6-51.1

Table 3: Available micronutrient status of the soils of Jammu region

Agro-climatic zone	Elevation Range (m)	No. of soil samples	Micro-nutrients (mg kg^{-1}) Fe	Cu	Zn	Mn
Sub-tropical	215-360	491	4.1-54.3 (13.50)	0.2-0.92 (0.45)	0.18-6.10 (1.11)	3.2-52.60 (18.2)
Intermediate	360-1000	1242	1.14-54.3 (10.55)	0.23-3.26 (0.71)	0.10-6.10 (1.31)	1.88-49.64 (9.54)
Temperate	1000-2500	81	3.3-17.4 (9.06)	0.31-1.21 (0.67)	0.28-6.40 (1.52)	4.9-248 (13.80)

Sulphur:
The content of available S in these soils varied from 8.0 to 51.1 mg kg^{-1} with mean values of 20.4, 23.8 and 29.6 mg kg^{-1} in sub-tropical, intermediate and temperate zone soils, respectively (Table 2). Considering 10 ppm as the critical limit, Raya, Lakhanpur and Samba soils in the sub-tropical zone and accounting for 20% soils, were deficient in this element.

Micronutrient status

Zinc:
The available Zn content in the soils of three agro-climatic zones varied from 0.18 to 6.40 mg kg^{-1} with mean values of 1.11, 1.31 and 1.52 mg kg^{-1} in sub-tropical, intermediate and temperate zone soils respectively (Table 3). Considering 0.60 mg kg^{-1} as the critical level of Zn deficiency (Bansal *et al.*, 1980) the percentage of samples deficient in sub-tropical, intermediate and temperate soils were 26, 24 and 10 per cent, respectively. The Zn deficiency is more in sub-tropical zone soils due to higher pH, low organic matter and to some extent sodic nature of some soils. The potential deficient areas are R.S. Pura, Hiranagar, Dayalachak and Samba, as this is food bowl of Jammu region and for obtaining potential crop yields and full benefit from costly inputs of fertilizers etc., it is imperative to mitigate Zn deficiency from these soils with zinc application.

Copper:
The amount of available Cu varied from 0.20 to 3.26 mg kg^{-1} (Table 3). The mean values of Cu were much higher than the critical limit of 0.2 ppm (Follet and Lindsay, 1970). None of the soil samples were deficient in Cu. Although the content of OC was low in sub-tropical zone soils, still the nature of metallo-organic complexes of Cu could be such that have constituted the bulk of the available Cu pool in the investigated soils.

Manganese:
The content of DTPA-available Mn in these soils varied from 1.88 to 52.60 mg kg^{-1} with mean values of 18.2, 9.54 and 13.80 mg kg^{-1} in sub-tropical, intermediate and temperate zone soils respectively (Table 3). Considering 1.0 mg kg^{-1} DTPA-extractable Mn (Follet and

Lindsay, 1970) as the critical limit, none of theses soils samples were deficient in Mn.

Iron:

The available Fe content of the soils under investigation varied from 1.14 to 54.3 mg kg^{-1} (Table 3). Considering 4.5 mg kg^{-1} DTPA extractable Fe as the critical limit (Lindsay and Norvell, 1978) the percentage of soil samples deficient in Fe were only 3 in intermediate zone soils. The soil samples analysis compliment the information that the soils of three agro-climatic zones are deficient in N, K, S and Zn and are adequate in Fe, Mn, Cu and P. The pH, EC, OC, CEC, primary and secondary macro and micronutrients vary significantly across the three agro-climatic zones.

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Research Article

Effect of weed control on weeds, grain yield and its components of maize (*Zea mays* L)

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ABSTRACT
The present study entitled "effect of weed control on weeds, grain yield and its components of maize (*Zea mays* L.) cv. Single cross-10 was carried out at the Agricultural and Experiments Research Station at Giza, Faculty of Agriculture, Cairo University, Egypt. The experiment was conducted in the summer 2017 and was repeated in 2018 on the same piece of land to conform previous findings. The experiment design was Randomized Complete Block design (RCBD) having three replications. Six treatments include atrazine (1.0 kg/ha), glyphosate (0.8 kg/ha). atrazine + glyphosate, one hand hoeing after three weeks, hand hoeing twice after three and five weeks from sowing and weedy chick as control were used. Results indicated that glyphosate was found superior to atrazine for all studied characters. Moreover, lower weed dry matter accumulation and higher weed control % as well as higher values of ear characters (ear length, ear diameter, grain weight/ear and shilling %) and grain yield per unit area were recorded in tank mix application of atrazine + glyphosate followed by hand hoeing twice.
Keywords: Maize, yield, yield components and weed control.

INTRODUCTION
Maize (*Zea mays* L.) occupies the key place in the cropping system of Egypt for it is a short duration crop and provides a more economic return to the farmers. It is the third most important staple food crop both in terms of area and production after wheat and rice in Egypt. The total area under cultivation of maize in Egypt is about 1.03 million hectares which is about 25.2% of the total cultivated agricultural land, which the average yield is 8.3 t/ha (FAOSTAT, 2016). Therefore, increasing maize production is an important goal to reduce the gap between production and consumption through expanding the maize cultivated area and increasing productivity per unit area. Consequently, increasing maize production under Egyptian conditions is major concern of agronomists. Despite average yield of maize is very low. The reassures for low yield are many, but one of the most serious and less noticeable, is the competition of weeds. Weeds have such significant effects on crop yield because they interfere with normal growth of crop, through competition for nutrients, moisture, space, sunlight, carbon dioxide and water. Weeds also serve as host for various pests and deceases that produce chemical substances that can be allergens or toxins to crop plant. There are also indication that weeds limit the choice of crop rotation sequences and culture practices (Patel *et al*., 2013). Moreover, weeds constituent one of the major economic important problem for maize growers, because they can reduce yield up 80% (Konnan and Chinnagounder, 2013), 20 - 100 % (Madhaevi *et al*., 2014), 83% (Ehsas *et al*., 2016), 18 -855 (Jagadish *et al*., (2016) and 335 (Kakade *et al*., 2016). The mechanical method of weed control is however the most commonly used method, very laborious, time consuming and very expensive, especially in the hot. Many previous researchers found that the maximum and minimum weed density and dry weight of all major weed species were recorded in hand hoeing treatments (Ahmed and Susheela, 2103; Kumar *et al*., 2013; Deshmukh *et al*., 2014; Samanth *et al*., 2015; Swetha *et al*, 2016 and Kumar,2017). On the other hand, chemical control method is quick, more effect, time and labor saving method than others. Herbicides controlled 65 - 90% of weed flora and gave 100 -105% more maize yield than weedy cheek (Nadeem *et al*., 2005). Consequently, the present study aimed to investigate the effect of weed control on weeds, grain yield and its components of maize (*Zea mays* L.)..

MATERIALS AND METHODS
The present study entitled "effect of weed control on weeds, grain yield and its components of maize (*Zea mays* L.) cv. Single cross-10 was carried out at the

Agricultural and Experiments Research Station at Giza, Faculty of Agriculture, Cairo University, Egypt. The experiment was conducted in the summer season 2017 and was repeated in 2018 on the same piece of land to conform previous findings. The experiment design was Randomized Complete Block design (RCBD) having three replications. The net plot area was 10.5m^2 (5 ridges, 3m long and 70cm apart). The soil type was clay loam in texture having 1.7 organic matter, 48.2ppm available N, 14.5ppm available P, 367.5ppm available K, 7.7 pH and 2.4 mmohs/cm 25c^0 Ec (average of both seasons). Six treatments include atrazine alone (1.5 kg/ha), glyphosate alone (0.8 kg/ha). atrazine + glyphosate, one hand hoeing after three weeks, hand hoeing twice after three and five weeks from sowing and weedy chick as control were used (Table 1).

Table 1: List of weed control treatments used in both season.

Trade name	Common name	Dose/ha
Atrazine	Basta	1.5 kg
Glphosate	Touchdown (roundup)	0.8 kg
Atrazine + glphosate	Basta + Touchdown (roundup)	1.5 kg+ 0.8kg
One hand hoeing	-	-
Two hand hoeing	-	-
Unweeded (control)	-	-

Two grains of Maize (cv. Single cross 10)) were sown manually in each hill at 25cm spacing and irrigation was followed. Date of sowing was in the fourth week of May in both seasons. Thinning to one plant/hill was done before the first irrigation (3 weeks after sowing). The recommended amount of nitrogen (urea 46.5%) and phosphorus (DAP) were applied. Half of nitrogen and the whole of phosphorus were drilled in ridges at the time of sowing and the reaming half of nitrogen was applied before the first irrigation. All other agronomic practices followed uniformly for all treatments through the growing seasons. Herbicides at the recommended doses were applied in the plots at 4th week after sowing of maize followed by irrigation. The herbicides were applied by a knapsack-sprayer using 700 L water/ha. The data on weed biomass was collected at 90 days after sowing from 1m^2 in each plot. The collected weeds were dried in the sun and then in a electrical oven for 48 hours maintain a constant temperature of 75c^0. After drying, weight of dry weeds (g/m^2) was measured. At harvest, plant height, grain weight/ear, 100-grain weight and grain yield per unit area were estimated. The recorded data were analyzed by using statistical software package MSTAT-C (Michigan State University, 1990). Least significant differences (L.S.D.) at 0.05% probability was employed to test the significant differences among mean value of each treatment (Steel and Torrie, 1997).

RESULTUS AND DISCUTION

Effect on weeds

The results presented in Table (2) indicated that the experiments were infested with several broad leaf and grasses weeds.. The family Compositae included *Xnthum pongens*, while Ceperaceae included *Cyperus rotundus* and Euphorbiaceae included *Euphorbia geniculala*. The family Poaceace predominated the other families having three species viz. *Brachiaria eruciformis*, *Echinochloa colonum*, , *Cynodon dactyilon. Moreover, Portulaceae and* Tiliaceae included *Portulacae oleracea* and *Corchorus olitorius, respectively (*Table 2*).*

Table 2: Prevailed weeds in the experimental area in both season.

Botanical name	Family	English name
Amaranthus oleraceeaa L.	Amaranthaceae	Pigweed
Xnthum pongens L.	Compositae	Cocklebur
Cyperus rotundus L.	Cyperaceae	Purble Nutsedge
Euphorbia geniculala L.	Euphorbiaceae	Spurge
Echinochloa colonum L.	Poaceae	Grass Jungle
Prachiaria eruciformis L.	Poaceae	Broadleaf
Cymodon dactylon L.	Poaceae	Eermoda grass
Portulacae oleracea L.	Portulaceae	Pursian
Corchorus olitorius L.	Tiliaceae	Nalta Jute

Concerning dry weight of weeds/m^2, results in Table (3) showed that atrazine plus ghlphosate followed by hand hoeing twice reduced dry weight of weed/m^2 compared with other treatments. On the other hand, either atrazine alone or ghlyphosate alone and one hand hoeing were moderate in controlling grassy weeds compared to unwedded (control) in both seasons. Moreover, atrazine + glyphosate, hand hoeing twice, atrazine alone, glyphosate alone and one hand hoeing reduced the dry weight of total weeds by (84.1 and 114.7 gm), (69.7 and 78.5 gm), (34.5 and 35.1 gm), (24.6 and 25.1 gm) and (14.5 and 19.8 gm) than those that in control (112.6 and 135.3 gm) in both season,

respectively. Therefore, weed control (%) over the untreated control were (74.7 and 84.6%),(61.9 and 58.0%). (30.7 and 25.9%), 21.8 and 18.6%) and (12.9 and 14.6%) in both seasons, respectively. Generally, atrazine + glyphosate was the best in controlling weeds in maize followed by hand hoeing twice. On the other hand, ghlphosate alone followed by one hand hoeing was the poorest in decreasing dry weight of total weeds in both seasons. The reduction in dry weight of weeds may be due to the phototoxic effect of herbicides on weeds. This findings are in harmony with the previous work of Madhavi *et al*. (2014), Samanth *et al*. (2015), Stanzen *et al*. (2016), Kumar *et al*. (2017) and Suhoo *et al*. (2017) who reported that the minimum dry weight of all major weed species and the maximum grain yield of maize were recorded in two hand hoeing and application of different herbicides. Moreover, Tahir (2007) indicated that the lower weed dry weight due to herbicide and manual hoeing application over weedy check might have been due to the mortality of weeds in these treatments while, the maximum weed dry weight was found in weedy check due to unchecked weed growth as no weed control practices were applied.

Table 3: Effect of weed control treatments on dry weight of total weeds (gm/m^2) and weed control (%) in both seasons.

Treatments	Dry weight of total weeds	Weed control (%)	Dry weight of total weeds	Weed control (%)
	First season (2017)		Second season (2018)	
Atrazine	78.1	30.6	100.2	25.9
Glyphosate	88.0	21.8	110.2	18.6
Atrazine + ghlyphosate	28.5	74.9	20.6	84.8
One hand hoeing	98.1	12.9	115.5	14.6
Two hand hoeing	42.9	61.9	56.8	58.0
Nunweeded (control)	112.6	00.0	135.3	00.0
L.S.D.	8.3		6.8	

Table 4: Effect of weed control treatments on plant height, ear length, grain weight/ear, 100-grain weight and grain yield in the first season.

Treatments	Plant height (cm)	Ear length (cm)	Grain Weight /ear (g)	100-grain Weight (g)	Grain Yield (t/ha)	Relative increase (%) increase
Atrazine	269.1	21.4	224.1	39.1	3.7	48.0
Glyphosate	267.2	21.2	215.5	36.9	3.3	32.0
Atrazine + Glyphosate	273.3	23.9	230.2	43.1	4.6	84.0
One hand hoeing	265.1	21.0	210.3	37.5	3.9	56.0
Two hand hoeing	271.2	22.9	227.2	41.3	4.2	68.0
Nunweeded (control)	260.0	20.8	160.5	33.2	2.5	00.0
L.S.D.	2.1	1.0	3.0	2.2	0.4	

Table 5: Effect of weed control treatments on plant height, ear length, grain weight/ear, 100-grain weight and grain yield in the second season.

Treatments	Plant height (cm)	Ear length (cm)	Grain weight /ear (g)	100-grain Weight (g)	Grain Yield (t/ha)	Relative increase (%) increase
Atrazine	270.1	20.2	210.1	40.3	3.8	65.2
Glyphosate	268.6	20.1	205.3	38.7	3.5	52.2
Atrazine + Glyphosate	276.2	23.3	225.3	44.1	4.4	91.3
One hand hoeing	266.8	20.3	200.1	35.8	3.1	34.8
Two hand hoeing	272.5	22.7	220.2	42.5	4.1	78.3
Nunweeded (control)	262.1	20.2	165.3	34.2	2.3	00.0
L.S.D.	3.8	2.3	4.3	1.6	0.3	

Effect on grain yield and its related traits

The final grain yield of maize crop is a function of combined effect of ear characters and number of ears per unit area which were affected by the management practices. The results presented in Table (4 and 5) raveled that plant height, ear length, grain weight/ear, 100-grain weight and grain yield per unit area were significantly affected with all tested treatments in both seasons. The tallest plants (273.3 and 276.2 cm), the highest ear length (23.9 and 23.3 cm), the highest grain weight/ear (230.2 and 225.3 gm) the highest 100-grain weight (43.1 and 44.1) and the highest grain yield (4.6 and 4.4 t/ha) were recorded with application of atrazine

+ glyphosate in both seasons, respectively. On the other hand, the other evaluated treatments showed an intermediate effect. Moreover, weed infested plots gave the shortest plants (260.0 and 262.1 cm), shortest ear length (20.8 and 20.2 cm), lowest grain weight/ear (160.5 and 165.3 gm), lowest 100-grain weight (33.2 and 34.2 gm) and the lowest grain yield (2.5 and 2.3 t/ha) in both season, respectively. It is quite clear from the demonstrated results that application of atrazine + ghlyphosate significantly increased grain yield by 84% in the first season and by 91% in the second one over the infested control. Such results may be due to the better control of weeds by mixture of the two tested herbicides which contribute to higher grain yield. The increment in grain yield was mainly because of more ear length, grain weight/ear and 100-grain weight over weedy check which recorded the lowest grain yield could be attributed to maximum weed density which suppressed the growth and development of maize plants by competing for moisture, light and nutrients (Tahir, 2009). These results are agreement with those obtained by many researchers (Stanzen *et al*., 2016; Kumar *et al*., 2017; and Sahoo *et al*., 2017) who reported that either herbicides or hand hoeing significantly decreased weed population and competition over control and maximum grain yield was obtained.

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Research Article

Formulation of weather based forecasting model for mustard aphid, *Lipaphis erysimi* kalt. in Tarai region of Uttarakhand

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ABSTRACT

Lipaphis erysimi (Kalt.) infestation on mustard account for significant yield losses in India. Experimental data from sixteen years were used to study the role of weather on the incidence and development of mustard aphid. Temperature was found to regulate the aphid population build-up and arrival . Weather parameters before one week from aphid population observation contribute higher effect than of the same date, two week prior and three week prior observation. In the present investigation regression equation between aphid incidence and using previous week's weather data could be used for formulating the forecasting model for *L. erysimi*, and for taking control measures.

Keywords: *mustard, aphid, forecasting model, weather parameter, regression method.*

INTRODUCTION

Agriculture sector plays an important role in India's social security and overall economic welfare. Oilseeds crops are the second most important determinant of agricultural economy, next only to cereals. India has the 5th largest vegetable oil economy in the worldaccounting for 7.4% world oilseed output, 6.1 % of oil meal production, 3.9% world oil meal export, 5.8% vegetable oil production, 11.2% of world oil import and 9.3% of the world edible oil consumption next to USA, China, Brazil and Argentina. Rapeseed-Mustard is the main oilseed crop for the Rabi season which is planted on more than 80% area covered under oilseeds (Patel *et al.*, 2017). Among abiotic factors, its environmental sensitivity is considered to be foremost i.e. instability of mustard plant under different environmental conditions. Understanding of pest population dynamics in relation to weather factors can help in better management of pests (Patel and Singh, 2017). The data on pest infestation and weather parameters in a particular area over a long period of time can be used to develop pest weather models, which can then be used for agro-ecological pest zoning. Forecasting models are developed based on pest population relation with weather parameters of current or one or two lag weeks. However, peak pest incidence during a season may be the function of weather parameters of several preceding weeks or months Reliable and well-timed forecasts are of vital importance for appropriate and up-to-date planning's especially for agriculture which is full of uncertainties. The dynamics of insect-pests and diseases will pose considerable threats to rapeseed mustard production. Both biotic and abiotic factors are responsible for pest population dynamics (Singh *et al.*, 2009).

Environmental parameters such as temperature, rainfall, sunshine hours and relative humidity greatly influence the outbreak of the insect population (Siswanto, Dzolkhifli and Elna, 2008). Pest population density solely depends on climatic factors of several preceding weeks or months. It thus becomes mandatory to find out the relationship of pest population with weather parameters of several preceding weeks. Knowledge of the seasonal incidence and population build up trend is essential to ensure timely preparedness to challenge impending pest problems and prevent yield losses (Das *et al*., 2008). Keeping this in view, present research was undertaken to formulate and validate weather-based forecasting model for the Tarai region of Uttarakhand, India.

MATERIALS AND METHODS

Forewarning model based on the weather factors as independent variables at the time of first arrival of aphid on mustard as dependent variables were suited by multiple regressions based on correlation coefficients between dependent variables under study with the respective weather parameter in different weeks. The historical data of eighteen years from 1998-99 to 2014-15 for Tarai region of Uttarakhand collected from annual progress reports of AICRP of rapeseed mustard,

Pantnagar, India. Sixteen years weather data with respect to different parameters was arranged week-wise, starting from onset of aphid population to migration of aphid population, standard week for all the years have used for model development. In order to normalize aphid population, square root transformed values were used in the analysis. Square root transformed peak mustard aphid population over the years were correlated with weekly values of each of the weather parameters separately, beginning with onset of aphid population until week of peak aphid population. In this way, most important week in relation to different weather parameters that influenced aphid population was detected. Values of each of the weather parameters during the most important week thus identified were used to develop a multiple linear pest-weather model. The model was validated through 2- year independent data on weather parameters and mustard aphid population which not be used for developing the model. These data was not be used in model development. The model performance was evaluated by comparing observed and predicted aphid population.

RESULTS AND DISCUSSION

To predict first arrival of aphid population, regression equations were used having high coefficient of determination and low error as well as test of statistical significance. Significant equations have been developed and tested on the basis of R^2 and standard error. It was found that the multiple linear equation developed for the weather data observation one week prior to peak aphid population has higher R^2(0.71) with standard error 2.72 but predicted same population of aphid with corresponding weather conditions, in comparison to the observed data of experimental year 2015-16 and 2016-17(Table 1). Pest–weather model between mustard aphid, *L. erysimi* (Kalt.) and all weather parameters was established as follows (Equation 2, Table 1).

$$Y=31.58+2.08T_{MAX} -2.76T_{MIN} -0.87RH1+0.65RH2-0.03RF-1.50SS+2.13WS$$

Weather parameters explained 70% variability in *L. erysimi* (p = 0.08). However, removal of WS(wind speed) resulted in an appreciable reduction in coefficient of determination (R2 = 0.49) rather it decreased, thereby indicating significant influence of WS on *L. erysimi* population(Equation 2, Table 1). Likewise, exclusion of SSH (sunshine hours) cause a significant reduction in R2 (0.32), suggesting significant role of SSH on mustard aphid population. However, exclusion of RF (rainfall) did not cause any reduction in R2 (0.31) suggesting insignificant role of RF on *L. erysimi* (Equation 3, Table 1). Further, RH1 was excluded and model with Tmax, Tmin, and RH1(relative humidity) could account for only 0.23 % variability in aphid population, thereby suggesting significant role of morning relative humidity (Equation 2.4, Table 1).

The observed and predicted values for aphid population using regression model for one week prior to aphid population have been presented in table 2. It is evident from the data, predicted points were found to be grater close proximity with observed data. RMSE was found to be 3.96 aphids for historical data points and RMSE (4.52 aphids)for observed data. Test of significance of the regression model (R^2 0.71) shows that wind speed and sunshine play a significant role in onset of aphid population after one week. The regression model of weather parameters of two and three weeks prior to aphid observation showed various contradictory data points. Due to erratic weather conditions observed from last sixteen years and also affected aphid population trend. Due to smaller coefficient of determination and higher standard error in model, developed for two and three week prior forecasting was underestimated. A large variation in the R^2 values was found in on same date, one week , two week and three week before. The possible reason for this could be the marked variation in sowing dates and abnormal weather conditions like minimum temperature and morning relative humidity in weather parameters and their partial coefficients determination (R^2) are shown in Table 1.

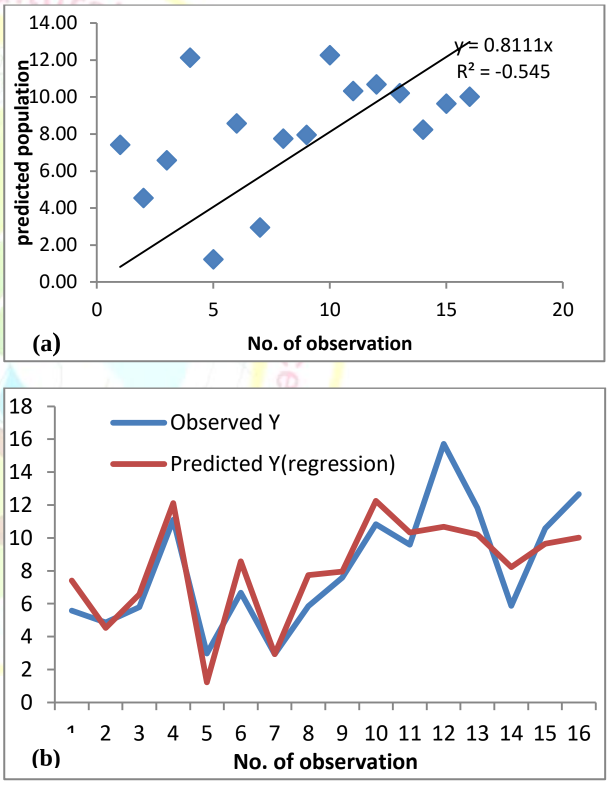

Fig. 1: Observed and predicted aphid population with one week before weather parameters (a,b)

Lowest R^2 value indicates non -significant effect of weather parameters on the same date, two week prior and three week prior population observation. However, during establishment phase, minimum temperature has significant contribution in population build up. Weather parameters before one week from aphid population observation contribute higher effect than of the same date, two week prior and three week prior observation. Where, minimum temperature and morning relative humidity significantly influenced the aphid population. The study is in conformity with the report of Dhaliwal *et al.* (2007) which stated the similar results of R^2 value which was 0.42.

Table 1: Equation developed by taking four time periods of weather variables with aphid population

Eq. no.	Regression equation obtained	R^2	SE	F_{sig}
On same date				
1	$Y= 114.56-1.66X_1+2.65X_2-0.46X_3-0.71X_4-0.01X_5-1.68X_6-0.12X_7$	0.57	3.29	0.27
1.1	$Y= 112.44-1.66X_1+2.61X_2-0.44X_3-0.71X_4-0.02X_5-1.68X_6$	0.57	3.12	0.16
1.2	$Y= 90.64-2.02X_1+2.47X_2-0.37X_3-0.46X_4+0.003X_5$	0.44	3.37	0.24
1.3	$Y= 91.12-2.03X_1+2.5X_2-0.38X_3-0.46X_4$	0.44	3.22	0.13
One week before				
2	$Y= 31.58+2.08X_1-2.76X_2-0.87X_3+0.65X_4-0.03X_5-4.5X_6+2.13X_7$	0.71	2.72	0.08
2.1	$Y= 21.29+2.24 X_1-2.59 X_2-0.65 X_3+0.54 X_4+0.03 X_5-1.7 X_6$	0.49	3.38	0.2
2.2	$Y= 23.42+10.5 X_1-1.38 X_2-0.55 X_3+0.43 X_4+0.01 X_5$	0.32	3.71	0.5
2.3	$Y= 19.45+1.10 X_1-1.42 X_2-0.52 X_3+0.45 X_4$	0.31	3.56	0.33
2.4	$Y= 29.82+1.24 X_1-1.36 X_2+0.4 X_4$	0.23	3.60	0.33
Two week before				
3	$Y= -74.78+1.52X_1-1.06X_2+0.60X_3+0.14X_4-0.03X_5-1.13X_6+0.38X_7$	0.31	4.20	0.80
3.1	$Y= -81.26+1.86X_1-1.14X_2+0.59X_3+0.19X_4-0.03X_5-1.24X_6$	0.30	4.0	0.68
3.2	$Y= -48.44+1.49X_1-0.69X_2+0.16X_3+0.28X_4-0.05X_5$	0.25	3.9	0.65
3.3	$Y= -20.02+1.49X_1-0.88X_2-0.12X_3+0.26X_4$	0.17	3.9	0.69
Three week before				
4	$Y= -132.66-0.34X_1+0.33X_2-0.85X_3-0.44X_4-0.005X_5-1.9X_6-1.35X_7$	0.52	3.50	0.38
4.1	$Y= 101.43-0.65X_1+0.03X_2-0.56X_3-0.36X_4+0.03X_5-1.42X_6$	0.41	3.66	0.45
4.2	$Y= 103.21-1.16X_1+0.28X_2-0.65X_3-0.23X_4-0.02X_5$	0.35	3.64	0.42
4.3	$Y= 109.60-1.25X_1+0.21X_2-0.69X_3-0.25X_4$	0.34	3.49	0.28

Where,
X_1 Maximum temperature (°C) X_5 Rainfall (mm)
X_2 Minimum temperature (°C) X_6 Sunshine (hours)
X_3 Morning relative humidity (%) X_7 Wind speed (km/hr)
X_4 Evening relative humidity (%)

Table 2: Observed and predicted aphid population by regression model (R^2=0.71)

Observation (Year)	Observed Y	Predicted Y	Residuals
1 (1998-99)	5.58	7.46	-1.88
2 (1999-2000)	4.86	4.54	0.32
3 (2000-01)	5.8	6.70	-0.90
4 (2001-02)	11.1	12.13	-1.03
5 (2002-03)	2.98	2.15	0.83
6 (2003-04)	6.67	8.57	-1.90
7 (2004-05)	2.93	7.44	-4.51
8 (2005-06)	5.86	7.48	-1.62
9 (2006-07)	7.58	10.16	-2.58
10 (2007-08)	10.84	12.81	-1.97
11 (2009-10)	9.58	10.26	-0.68
12 (2010-11)	15.71	10.96	4.75
13 (2011-12)	11.82	10.32	1.50
14 (2012-13)	5.88	7.85	-1.97
15 (2013-14)	10.59	9.57	1.02
16 (2014-15)	12.66	10.01	2.65
RMSE=3.96			
An independent data set(Predicted aphid population)			
17 (2015-16)	14.03	14.09	-0.062
18 (2016-17)	12.31	9.49	2.817
RMSE=4.52			

The population aphid exhibited negative correlation with maximum and minimum temperature, rainfall, wind velocity, evaporation and positive with afternoon and morning relative humidity. The values of coefficient of determination (R) were high (0.92 to 0.99), indicated that the population of mustard aphid greatly governed with the weather parameters. The temperature (maximum 18.7 and minimum 5.0 C), relative humidity (morning 91.5 and evening 50.5 percent), rainfall (000.0 mm), evaporation (below 1.55 mm), bright sun shine hours (below 5.8 hr) along with wind speed below 3.4 km/hr were found very conductive for *L. erysimi* (Hasan and Singh, 2010).

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Research Article

Stocks delineation of bull's eye fish (*Priacanthus hamrur)* in Indian water using morphometric measurements and meristic counts

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ABSTRACT
The Moontail bull's eye (*Priacanthus hamrur)* is one of the commonly available fish species found in the deep sea and under ledges or hovering next to coral heads during the day. In the present study, around 300 specimens were collected from different location in east and west coast of India including Kakinada, Kolkata, Cochin and Mumbai to investigate the stock differentiation among the populations. A total of 14 morphometric traits and 10 meristic counts were studied. The descriptive statistics of morphometric traits indicated the much larger growth in populations of west coast compares to the east coast. The meristic traits were not much efficient in identifying the stocks. Pre pelvic fin length, post anal fin length, post dorsal length, pre dorsal fin length, head length, eye diameter, body depth, caudal peduncle depth and dorsal fin base helped in the separation of stocks. All the four stocks have separate morphometric features. The present study will provide the baseline information on the stock characteristics of *P. hamrur* from Indian water and management measures of the resources for sustainable utilization.
Keywords: *Stock, Morphometric, Meristic and Resource.*

INTRODUCTION

Priacanthus hamrur is one of the most important emerging species among the commercial catches of Indian coast, but there is lack of information on its population structure, biology and population dynamics. Stock identification is the basic requirement of studying the different population parameter of the species. Stock identification of species is essential for fishery management because most applied population models assume that the group of individuals has homogeneous vital rates (e.g., growth, maturity, mortality). Stock deleneation is a central theme in fisheries science that involves the recognition of self-sustaining components within natural populations (Crandall *et al.,* 2000; Thorpe *et al.,* 1996). Patterns of morphometric variation in fishes may indicate differences in growth and maturation rates because body form is a product of ontogeny. The present study has been made to identify stocks of *Priacanthus hamrur* using meristics and traditional morphology which give a good insight into the stock relationships of this species. Better management practices can be attempted based on findings of the present study.

MATERIALS AND METHODS

During the study, samples of *P. hamrur* was collected from landing centres of Versova (Maharashtra) & Cochin (Kerala) on the west coast and Kakinada (Andhra Pradesh) & Digha (West Bebengal) during October 2017 to January 2018 (Table 1 and Figure 1). *P. hamrur* was identified by following the description given by FAO species identification sheets (Russell, 1990). A total of 279 fish samples of *P. hamrur* were collected during the present study were studied for stock identification. The collected specimens were placed in the insulated fish boxes lined ice and taken to the laboratory for further study. The Samples were cleaned thoroughly in running water to remove the slime or dirt and kept in a freezer at -20^{0}C. The frozen samples were thawed adequately for before studies.
A total of eleven meristic characters were taken into account for the present study (Table 2). The meristic characters counted following the widely accepted method provided by Hubbs and Lagler (1958). The operculum of the left side of fish removed by cutting the gill cover and first gill arch was removed to count the gill rakers on upper and lower gill arch. All counts and measurements are taken from the left lateral aspect of the fish. 14 morphometric measurements have been taken for a total of 279 specimens (Table 3 and figure 2).Google Earth used for marking fish landing center location. Data entry, editing, transformation and other statistical analysis was done in MS-Excel 2010, IBM SPSS and Statistica (Ver 12.).

Table 1: Details of sampling

Coast	East Coast		West coast	
Stock	Andhra Pradesh	West Bengal	Maharashtra	Kerala
Landing Centre	Kakinada	Digha	Versova	Cochin
Location	16.57^{O}N 82.15^{O}E	21^{O} 41 N 87^{O} 33 E	19.12^{O} N 72.82^{O} E	9.97^{O}N 76.28^{O}E
Date of sampling	20 Oct. 2017	10 Dec. 2017	13 Jan. 2017	25 Dec. 2017
Sample sizes (n)	88	64	63	64
Total	279			

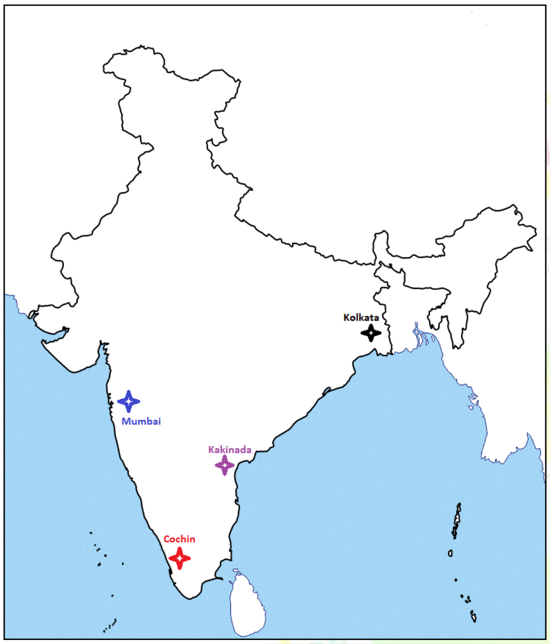

Figure 1: Location selected for sampling of Bull's eye, *Priacanthus hamrur*

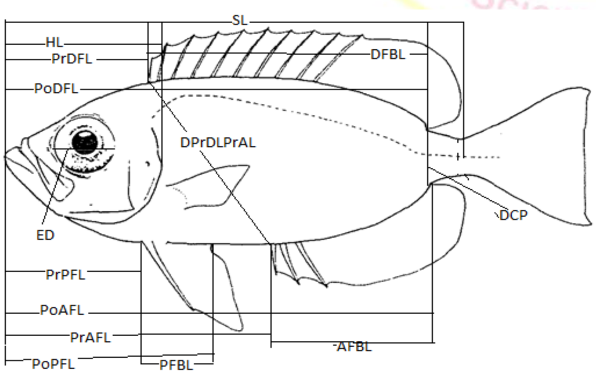

Figure 2: Diagrammatic representation of morphometric measurements of the body of *P. hamrur*

Table 2: Meristic traits of *P. hamrur*

S. No.	Meristic traits	Acronyms
1	Number of the dorsal fin spines	DFS
2	Number of the dorsal fin soft rays	DFR
3	Number of the pectoral fin rays	PFR
4	Number of the pelvic fin spines	PEFS
5	Number of the pelvic fin rays	PEFR
6	Number of the anal fin spines	AFS
7	Number of anal rays	AFR
8	Number of caudal fin rays	CFR
9	Number of total gillrakers on the first gill arch	GR
10	Number of branchiostegal rays	BGR
11	Number of scales on the lateral line	SAL

Table 3: Morphometric traits of the body of *P. hamrur*

Sl. No	Morphometric traits	Acronyms	Description
1	Standard length	SL	Distance between the tip of the snout and the base of the caudal fin rays
2	Head length	HL	Distance from the tip of the snout to the posterior margin of the operculum
3	Eye diameter	ED	Diameter of the eye along the body axis
4	Pre dorsal length	PrDL	Distance from the tip of the snout to the origin of the dorsal fin
5	Post dorsal length	PoDL	Distance from the tip of the snout to the end of the dorsal fin
6	Dorsal fin base length	DFBL	Distance between the origin and end of the dorsal fin
7	Pre pelvic fin length	PrPL	Distance from the tip of the snout to origin of the pelvic fin
8	Post pelvic fin length	PoPL	Distance from the tip of the snout to end of the pelvic fin
9	Pelvic fin base length	PFBL	Distance between the origin and end of the pelvic fin
10	Pre anal fin length	PrAL	Distance from the tip of the snout to origin of the anal fin
11	Post anal fin length	PoAL	Distance from the tip of the snout to end of the anal fin
12	Anal fin base length	AFBL	Distance between the origin and end of the dorsal fin
13	Depth of insertion of anal and dorsal fin	DPC	Distance between insertion of the dorsal fin and the insertion of the anal fin.
14	Distance between dorsal fin origin and anal fin origin	DPrDL PrAL	Distance between dorsal fin origin and anal fin origin

RESULTS AND DISCUSSION

Meristic Counts

The descriptive statistics of the meristic traits *viz.* minimum, maximum, mode and range is presented in table 4. In the present study ten meristic traits were considered, to characterize the stock of *Priacanthus hamrur*. Out of ten meristic traits four traits, such as dorsal fin spines, pelvic fin spines, anal fin spines and branchiostegal rays showed no variation. The range value was higher for the number of pectoral fin rays, dorsal fin rays, gillrakers and the lateral line scale. The total gillrakers count on the on the first gill arch, has minimum and maximum values of 20 and 25, respectively, in all the stocks. The number of dorsal and pectoral fin rays also shows a little variation in range values with fish stocks. The Kolkata and Mumbai stocks possess less number of scales on the lateral line when compare to the Kakinada and Cochin stocks. The mode value of all the meristic traits except the dorsal fin spines, anal fin spines, pelvic fin spines and the branchiostegal rays varied between the four stocks (Table 5). The mode values clearly indicate the variation of different meristic traits between the four stocks of *P. hamrur* along the Indian coast. The minimum and maximum values of the meristic traits did not show much variation between sexes, however the range of dorsal fin rays, anal fin rays and branchiostegal rays showed variation (Table 5)

Morphometric characters

Descriptive statistics viz. minimum, maximum, mean, standard deviation and coefficient of variance estimated for morphometric traits of *P. hamrur* are presented in table 5. The standard length of fish, ranged from 11.91 to 27.54 cm for all the stocks. The standard length ranged from 11.91 to 27.54 cm for the males and 12.01 to 26.95 cm for females. The standard length of the collected samples ranged from 11.91 to 27.54 cm with value coefficient of variance as 22.43% (Table 6).The mean standard length observes was 19.56 cm. The head length of the sample ranged from 3.01 to 9.58 cm with a coefficient of variance of 22.94% (Table 5).

Table 4: Overall descriptive statistics of meristic traits

TRAITS	MIN	MAX	RANGE	MODE	CV (%)
Dorsal fin spines	10	10	0	10	0.00
Dorsal fin rays	12	15	3	14	3.95
Pelvic fin spines	1	1	0	1	0.00
Pelvic fin rays	4	5	1	5	10.65
Anal fin spines	3	3	0	3	0.00
Anal fin rays	11	15	4	14	5.29
Pectoral fin rays	14	18	4	17	3.14
Gill rakers on the lower limb	20	25	5	24	3.49
Scales on the lateral line	100	110	10	110	2.26
Branchiostegal rays	8	8	0	8	0.00

Table 5: Overall descriptive statistics of morphometric traits of the body of *P. hamrur*

TRAITS	Mean	MIN	MAX	SD	CV (%)
SL	19.56	11.91	27.54	4.39	22.43
PrPL	6.11	3.88	8.80	1.38	22.61
PoPL	8.89	5.00	13.19	2.14	24.13
PrAL	11.03	6.01	15.71	2.52	22.82
PoAL	16.74	1.06	23.60	4.07	24.34
PoDL	16.80	10.01	23.50	3.84	22.87
PrDL	6.28	3.90	10.25	1.46	23.18
HL	5.97	3.01	9.58	1.37	22.94
ED	2.46	1.03	3.92	0.58	23.67
DPrDLPrAL	7.58	4.03	10.96	1.81	23.84
DCP	1.92	1.00	3.06	0.54	28.25
DFBL	10.93	6.04	15.63	2.59	23.74
PFBL	2.95	1.00	5.03	0.91	30.90
AFBL	6.44	2.97	9.42	1.57	24.41

Table 7: Comparison of morphometric characters of *P. hamrur*

Characters (cm)	Philip (1994)	Saker (2009)	Vidya (2010)	Present Study (2018)
Standard length	10.2-29.5	10.7 – 27.4	10 – 24.4	11.91-27.54
Head length	2.79-3.37	-	-	3.01-9.58
Eye diameter	1.13-1.6	-	-	1.03-3.92
Anal fin length	4.7-5.9	-	-	2.97-9.42
Pelvic fin length	2.6-3.22	-	-	1.00-5.03

Table 8: Comparison of fin formula of *P. hamrur*

Authors name	Fin formula
Koteswaramma (1982)	D, X+14; A, III+14; P, 18; V, I+5
Starnes (1988)	D, X +13-15; A, III+13-16; P, 17-20, GR, 24-26
Philip (1994)	D, X+13-15; A, III+14-15; P, 18-19, GR, 24-26
Present study (2018)	D, X+12-15; A, III+11-15; P, 14-18; V, I+4-5; GR, 20-25

The eye diameter varied from 1.03 cm to 3.92 cm with a coefficient of variance of 23.67%. The maximum eye diameter was observed in Mumbai stock and minimum in Kakinada stock (Table 6). The caudal peduncle depth of the collected sample varied from 1.00 to 3.06 cm (Table 5). In the present study, the head length was found to be smaller in Kakinada stock (Table 6).

Meristic traits:

Meristic characters are the numbers of discrete, and serially repeated countable characters. Koteswaramma (1982) has recorded number of meristic characters dorsal fin spine (10), dorsal fin ray (12-15), anal fin spine (3), anal fin ray (11-15), pelvic fin spine (1),

Table 6: Stock wise descriptive statistics of morphometric traits of the body of *P. hamrur*

TRAITS	EAST COAST							WEST COAST												
	KAKINADA					KOLKATA		COCHIN								MUMBAI				
	Mean	MIN	MAX	SD	CV (%)	Mean	MIN	MAX	SD	CV (%)	Mean	MIN	MAX	SD	CV (%)	Mean	MIN	MAX	SD	CV (%)
SL	13.87	11.91	17.47	1.14	8.25	23.97	19.03	27.54	1.64	6.85	20.84	19.02	23.34	0.90	4.31	22.14	15.05	25.00	1.95	8.81
PrPL	4.43	3.88	5.71	0.42	9.57	7.67	6.06	8.80	0.59	7.67	6.38	5.05	7.18	0.43	6.74	6.73	4.08	8.02	0.74	10.94
PoPL	6.25	5.00	7.92	0.73	11.71	11.27	9.05	13.19	0.94	8.38	9.51	8.03	10.98	0.65	6.79	9.70	6.07	11.86	1.09	11.20
PrAL	7.81	6.01	9.64	0.66	8.40	13.74	11.04	15.71	1.02	7.40	11.86	10.01	13.56	0.68	5.71	12.17	8.00	13.98	1.09	8.96
PoAL	11.86	10.00	15.02	1.06	8.95	20.73	16.07	23.60	1.40	6.77	17.52	1.06	20.08	3.23	18.43	19.04	13.07	21.65	1.66	8.73
PoDL	11.82	10.01	15.06	1.06	8.93	20.71	16.02	23.50	1.44	6.97	18.02	16.00	20.07	0.80	4.46	18.90	13.01	21.54	1.67	8.85
PrDL	4.58	3.90	6.27	0.52	11.47	7.96	6.08	10.25	0.82	10.30	6.50	6.00	7.57	0.44	6.84	6.83	4.09	8.16	0.75	10.96
HL	4.39	3.01	5.37	0.45	10.22	7.73	6.05	9.58	0.62	8.07	6.11	5.01	7.07	0.41	6.70	6.36	4.01	7.52	0.67	10.52
ED	1.96	1.03	2.67	0.26	13.31	3.22	2.04	3.92	0.30	9.26	2.34	2.00	2.91	0.32	13.50	2.53	1.03	3.30	0.48	19.02
DPrDLPrAL	5.24	4.03	6.67	0.54	10.27	9.15	7.01	10.96	0.76	8.27	8.24	7.06	9.42	0.45	5.44	8.76	6.03	10.76	0.88	10.09
DCP	1.26	1.00	1.92	0.25	19.77	2.30	1.08	3.06	0.36	15.58	2.19	2.01	2.55	0.17	7.88	2.24	1.08	2.92	0.31	13.88
DFBL	7.54	6.04	9.67	0.71	9.48	13.25	10.01	15.63	1.05	7.94	11.86	11.00	13.28	0.58	4.90	12.60	8.07	14.32	1.20	9.54
PFBL	2.05	1.00	3.27	0.59	28.52	3.72	3.00	5.03	0.64	17.10	3.20	2.01	4.48	0.58	18.18	3.21	2.03	4.82	0.72	22.43
AFBL	4.42	2.97	5.91	0.58	13.22	7.70	6.03	9.24	0.70	9.04	7.05	6.00	7.77	0.44	6.19	7.50	5.07	9.42	0.80	10.72

Pelvic fin ray (4-5), pectoral fin ray (14-18), lateral line scale (100-110), Total number of gillrakers (20-25) and branchiostegal rays (8) for *P. hamrur*. Whereas Starnes (1988) reported some variations i.e. dorsal fin spines (10), dorsal fin rays (13-14), anal fin spines (3), anal fin rays (14-15), pectoral fin rays (17-20), Lateral-line scales (70-90) and total gillrakers (22-26). The overall mode value of meristic traits found in the present study is almost similar to the above reports. In the present study, variations in meristic characters were less compared to morphometric characters. The variations between stocks were attributed to the gillrakers and scales on the lateral line. The variations in gillrakers of fishes and scale count due to isolation caused by differences in salinity gradients were also reported (Ikusemiju, 1975; Omoniyi and Agbon, 2007).

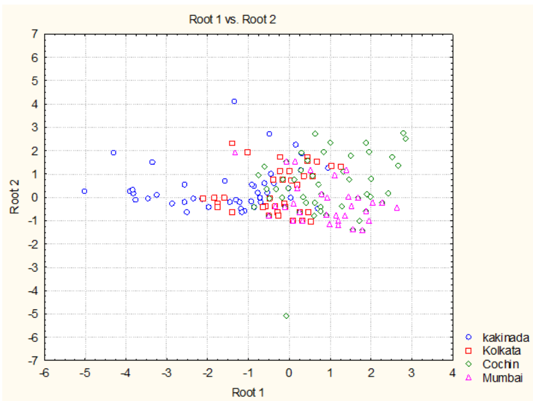

Figure 3: Scatter plot of four stocks based on different meristic counts

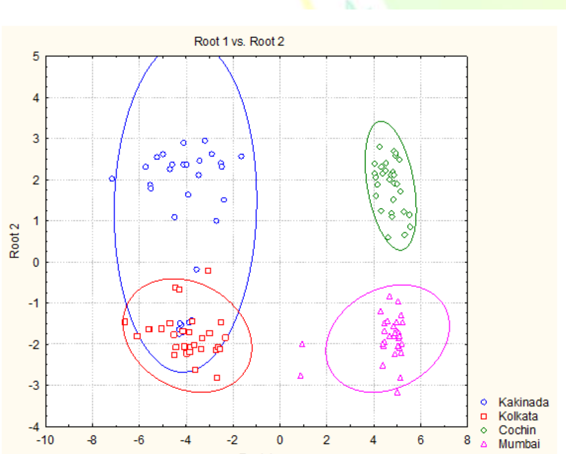

Figure 4: Scatter plot of four stocks based on morphometric variables

Morphometric traits:

Ecological and evolutionary process is the main reason for change in morphological structures of fishes. Polymorphism includes variation in behavior, change in morphology or life history traits in populations and is most commonly seen in vertebrate populations (Robinson and Wilson, 1994; Wimberger, 1994, Smith and Skulason, 1996). Environmental changes are susceptible to different morphometric traits of fish thus exhibit high plasticity of phenotypic characters in overall body shape where phenotypic plasticity is the ability of a genotype to respond to an alternative environmental condition producing an array of phenotypes (Thompson, 1991). The relationships between standard length and rest variables were analysed by using linear regression analysis. The minimum and maximum standard lengths observed in the present study were 11.91 cm and 27.54, respectively. These values are lower than those reported by Saker (2009). The minimum and maximum standard lengths observed by Saker (2009) were 10.7 cm and 27.4 cm, respectively. The average standard length of the fish collected from Kolkata was 23.97 cm which is comparatively higher than other stocks, whereas, the average standard length of the fish collected from Kakinada was 13.87 cm and it was the least among all the stocks. There is no significant difference ($P<0.05$) in average standard length between Cochin and Mumbai stocks.

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Research Article

New record of Common Owlet Moth *Spirama helicina* (Hubner, 1831) (Lepidoptera: Erebidae: Catocalinae) from Aligarh (Uttar Pradesh) with systematic account, distribution, host plants and biological control

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ABSTRACT
The present communication deals with the new record of *Spirama helicina* (Hubner, 1831), the Common Owlet Moth from Aligarh (Uttar Pradesh) and its systematic account, distribution, life cycle, host plants and biological control.
Keywords: *New Record, Common Owlet Moth, Aligarh*

INTRODUCTION

Moth fauna of Aligarh (Uttar Pradesh) is very little known. Husain *et al*. (2020) recorded *Spoladea recurvalis* (Fabricius, 1775) with its systematic account, distribution, host plants and control measures. Ahmad *et al*. (2009), Ahmad & Ansari (2010), Ali & Choudhury (2009) and Muslim *et al*. (2017) dealt with other aspects of some moths, viz. *Earias vitella*, *Helicoverpa armigera*, *Spodoptera littoralis*, *S. litura* and *Plutella xylostella*.

Recently, a brightly coloured moth was sighted at Hayat Manzil, Qila Road, Aligarh which on examination found to be *Spirama helicina* (Hubner, 1831), the Common Owlet Moth, belonging to family Erebidae and being not recorded earlier, is reported here for the first time from Aligarh (Uttar Pradesh).

Study site: Hayat Manzil, Aligarh

Location: Aligarh is located at co-ordinates 27.88° N 78.08° E with an elevation of *ca*. 178 m between rivers Ganga and Yamuna in western Uttar Pradesh. Hayat Manzil is a residential kothi / bungalow (near AhmadI Blind School and Flyover Shamshad Market), Qila Road, Aligarh.

Climate: Humid subtropical. Summers (April-June) hot with maximum temperature reaching 47^{o} C in May, winters (December-February) cool with minimum temperature 0^{o} C in January and thick fog; monsoon season starts late June and continue till early September with high humidity 75% in August and av. annual rainfall 728 mm with maximum 235 mm in August.

Flora: In and around the study site (Husain *et al*., 2020; Saddam *et al*., 2017; personal communication from Er. T. R. K. Sherwani and others, Aligarh):

Trees: *Annona squamosa* (Custard Apple), *Araucaria columnaris* (Cook Araucaria), *Artocarpus heterophyllus* (Jackfruit), *Azadirachta indica* (*Neem*), *Citrus limon* (Lemon), *Citrus maxima* (Pomelo), *Cordia mixa* (*Lasura*), *Cycas revoluta* (Sago Palm), *Dalbergia sissoo* (Indian Rosewood), *Delonix regia* (Flame of Forest, *Gulmohar*), *Dypsis lutescens* (Areca Palm), *Ficus carica* (Fig), *F. elastica* (Rubber Tree), *F. religiosa* (*Peepal*), *Limonia acidissima* (Wood Apple), *Mangifera indica* (Mango), *Mimusops elengi* (*Maulshree*), *Morus alba* (White Mulberry), *Musa* sp. (Banana), *Carica papaya* (Papaya), *Phoenix dactylifera* (Date Palm), *Phyllostachys aurea* (Golden Bamboo), *Pithecellobium dulce* (Manila Tamarind), *Psidium guajava* (Guava), *Punica granatum* (Pomegranate), *Saraca asoca* (Asoka), *Vachellia nilotica*/*Acacia arabica* (Babool), *Wodyetia bifurcata* (Fox-tail Palm), *Ziziphus mauritiana* (Jujube) etc.

Flowering Plants: *Bougainvillea* sp., *Lilium* sp. (Day Lily, Spider Lily, Monsoon Lily, Ball Lily), *Calendula* sp., *Catharanthus roseus* (Sada-bahar), *Cestrum noctumum* (Raat-Rani), *Chrysanthemum* sp., *Combretum indicum* (Rangoon Creeper), *Geranium* spp. (Geranium), *Helianthus annus* (Sunflower), *Hibiscus* rosa-sinensis (Gurhal), *Ipomoea cairica* (Railway Creeper), *Jasminum sambac* (*Bela*), *Lawsonia inermis* (*Hina*), *Plumeria alba* (Pagoda or Wood Rose), *Pyrostegia venusta* (Flaming Trumpet), *Rosa* sp. (Rose), *Tabernaemontana divaricata*

(Crape Jasmine), *Tagetes* sp. (Marigold), *Viola* sp. (Pansy) etc.

Vegetables: *Abelmoschus esculentus* (Lady-finger, Okra), *Allium cepa* (Onion), *A. sativum* (Garlic), *Beta vulgaris* (Beet), *Brassica oleracea botrytis* (Cauliflower), *B. oleracea italic* (Broccoli), *B. oleracea* var. ? (Cabbage), *Brassica rapa* (Turnip), *Capsicum annuum* (Chilli), *Coriandrum sativum* (Coriander), Cucurbits (*Cucurbita pepo*- Pumpkin), *Cucumis sativus*- Cucumber, *Kheera* or *Kakri*; *Lagenaria siceraria*- Bottle Gourd; *Luffa acutangula*- Ribbed Gourd; *L. cylindrica* - Sponge Gourd; *Mormodica charantia*- Bitter-gourd), *Colocasia esculenta* (*Arvi*), *Curcuma longa* (Turmeric), *Daucus carota sativus* (Carrot), *Mentha spicata* (Mint), *Murraya keonigii* (Curry-*patta*), *Ocimum tenuiflorum* (Basil), *Phaseolus vulgaris* (Beans), *Raphanus sativus* (Radish), *Solanum melongena* (Brinjal), *S. lycopersicum* (Tomato), *S. tuberosum* (Potato), *Spinacia oleracea* (Spinach), *Trigonella foenum-graecum* (*Methi*), *Zingiber officinale* (Ginger), etc.

SPIRAMA HELICINA (HUBNER, 1831)

Common Owlet Moth

Systematic Account, Distribution and Life Cycle

Synonymy:

Speiredonia helicina Hubner, 1831 (1824). *Zutr. Samml. exot. Schmett.*, 3: 14, pl. 76, figs.437, 438 (type-locality: Berbic [error]).

Spirama japonica Guenee, 1852. *Hist. nat. Ins*., *Spec. gen. Lepid*., 7 (Noct. 3): 195 (type-locality: Japan).

Spirama aegrota Butler, 1881. *Trans. Ent. Soc. Lond*., 1881: 197 (type-locality: Tokyo, Japan).

Spirama retorta, Hampson, 1894 (*partim*, bright form), *Faun. Brit. India*, Moths, 2: 553-554.

Spirama retorta, Gurule, 2013 (*partim*, light form). *Taxonomic studies of moths* (*Lepidoptera*: *Heterocera*) *from Maharshtra, India* (Ph. D. Thesis, University of Pune, India).

Spirama helicina, Moore, 1878. *Proc. Zool. Soc. Lond*., 1878 (4): 849; Kyoun-Sik *et al*., 2005. *J. Ecol. Field. Biol*., 29 (4): 377; Gurule *et al*., 2010. *Flora and Fauna*, 16 (2): 297, 302, fig. 56; Gurule & Nikam, 2011. *Flora and Fauna*, 17 (1): 172; Sivasankaran *et al*., 2012. *Check List*, 8 (4): 761-762; Sivasankaran & Ignacimuthu, 2014. *J. Bombay nat. Hist. Soc*., 111 (3): 208; Sivasankaran *et al*., 2017. *Check List*, 13 (6): 1106; Paul *et al*., 2017. *International Journal of Current Research*, 9 (8): 56211.

Spirama cf. *retorta*, Sondhi & Sondhi, 2016. *Journal of Threatened Taxa*, 8 (5): 8762, 8772, fig. 162 (bright colourd).

Spirama sp. cf. *helicina*, Shubhlaxmi, 2018. *Birdwing Field Guide to Indian Moths*: 55, fig. 2 female.

Sighting: 1 example (female), 11.vi.2020, Hayat Manzil, Qila road, near Aligarh Muslim University Campus, Aligarh, by Er. T. R. K. Sherwani.

Classification: Class Insecta, order Lepidoptera Linnaeus, 1759, superfamily Noctuoidea Latreille, 1809, family Erebidae Leach, 1815, subfamily Catocalinae Boisduval, 1828, tribe Hypopyrini Guenee, 1852, genus *Spirama* Guenee, 1852. (followed Zahiri *et al*., 2011, as based on molecular phylogeny).

Note: The classification of the genus has been dealt differently by various workers. Hampson (1894), listed under family Noctuidae (subfamily Quadrifinae). Kyoung-Sik *et al.* (2006), animaldiversity, discoverlife and morebooks also tread under Noctuidae. Gurule & Nikam (2011, 2013), Shubhalaxmi *et al.* (2011), Shubhlaxmi (2018), Sivasankaran & Ignacimuthu (2014), Mishra *et al*. (2016), Sondhi & Sondhi (2016), Sivasankaran *et al*. (2017), Singh *et al*. (2018), mothsofindia, nic.funet.fi and taxonomicon_considered it under family Erebidae (subfamily Erebinae). Paul *et al.* (2016, 2017) and Singh & Ranjan (2016) also considered in family Erebidae but not mentioned the subfamily. Pathre *et al.* (2019) placed under subfamily Arctinae (family Erebidae). Sajap *et al.* (1997), Sajap & Samad (2000), Gurule *et al*. (2010), Kirti *et al*. (2011), Sivasankaran *et al*. (2012), Kirti & Singh (2013), Sanyal *et al*. (2013), Uniyal *et al*. (2013), Sekhon & Singh (2015) and indiabiodiversity kept in family Noctuidae (subfamily Catocalinae).

Figure 1. ***Spirama helicina*, the Common Owlet Moth (Courtesy: Er. T. R. K. Sherwani)**

Distribution:

Aligarh (Uttar Pradesh): Hayat Manzil, Qila road, Aligarh (new record).

Rest of India: Assam, Delhi, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Odisha, Punjab, Sikkim, Tamil Nadu, Tripura, Uttarakhand and West Bengal.

Elsewhere: Bangladesh, Cambodia, China, Hong Kong, Indonesia, Japan, Korea, Laos, Malaysia, Myanmar, Nepal, Philippines, Russia, Singapore, Sri Lanka, Taiwan, Thailand and Viet Nam.

Altitudinal Range: Vellagavi 1343- Doddabetta 2624 m in Western Ghats, Tamil Nadu part (Sivasankaran *et al*., 2012); Nilgiri Hills, Nilgiri dist. 2280-2623 m; Kodaikanal, Dindigul dist. 1343-2295 m (Sivasankaran *et al*., 2017).

Figure 2. *Spirama helicina*, the Common Owlet Moth
(Courtesy: Er. T. R. K. Sherwani)

Diagnostic Features:

Male: Yellowish-brown with characteristic colour pattern; antennae fasciculate; head and collar dark chestnut brown; thorax paler with dark bands; abdomen crimson with black medial stripe; fore-wing with a large 'inverted comma' mark, having ochreous and black edges and some white on inner edge of 'tail', centre fuscous black, looking like an eye; a curved line passing round the stigma; another excurved line below costa; two crenulated sub-marginal black lines and two more prominent lines within the margin; hind-wing with a fold on inner area, containing an erectile ridge of long hair, with indistinct sub-marginal lines; underside suffused with dull reddish-orange with sparsely distributed lines.

Female: Brighter and with little larger 'inverted comma' mark; crimson abdomen with black cross bands and triangular black marks; both wings with prominent crenulated black sub-marginal lines; underside bright reddish-orange with lines.

Wing-span: Male 64-76 mm, female 66-88 mm (as *S. retorta* including *helicina*, Hampson, 1894; projectnoah.org); male 68 mm, female 63 mm (as *S. retorta*, Gurule, 2013); 60-70 mm (as S. *helicina*, Wikipedia; as *S. retorta*, thehindu.com); male 64-76 mm, female 66-88 mm (as *S.* cf. *helicina*, Shubhlaxmi, 2018).

Life-span: 36-37 days (as *S. retorta*, thehindu.com).

Deimatic Display: The colour pattern on the wings at resting stage, looking like that of snake head with big eyes and slightly opened mouth, is perhaps indented as a device to scare off or momentarily distract or giving an opportunity to escape to its potential predators.

LIFE CYCLE: Since *Spirama helicina* and *S. retorta* have been considered synonyms, the life cycle of former has not been studied separately. Sajap & Samad (2000) studied the development of *S. retorta* on different food plants under laboratory conditions and found 412 and 255 eggs, 22.10 and 24.83 days for larval period, 10.51 and 11.32 days for pupal period and 36.51 and 37.94 days for adult life-span when fed on *Acacia auriculiformis*, the Ear-leaf Acacia and *A. mangium*, the Black Wattle, respectively. However, when fed on *Acacia crassicarpa*, the Red Wattle and *Falcataria moluccana* (= *Paraserianthes falcateria*), the Muluccan Albizia larvae did not survive.

HOST PLANTS: (Sajap *et al*., 1997; Sajap & Samad, 2000; Shubhlaxmi, 2018).

The caterpillars / larvae feed on *Acacia auriculiformis* (Ear-pod Wattle), *A. crassicarpa* (Red Wattle), *A. mangium* (Black Wattle), *Albizia lebbeck* (Lebbeck), *Falcataria moluccana* (= *Paraserianthes falcateria*) (Muluccan Albizia), *Senegalia pennata* (= *Acacia pennata*) (Climbing Wattle) and *Senna surattensis* (Glossy Shower) belonging to family Fabaceae.

BIOLOGICAL CONTROL: Sajap *et al.* (1997) found *Eocanthecona furcellata* (= *Cantheconidea furcellata*) and *Sycanus leucomesus* (Hemiptera), *Vespa affinis indosinensis* (Hymenoptera) and *Mallada basalis* (Neuroptera) feeding on soft-bodied arthropods including *Spirama retorta*. These predators may also be attacking *S. helicina* as both these species mostly co-exist.

Natural enemies generally play an important role in controlling the population of insect pests. The tachinid flies (Diptera), *Blepharella* sp., *Carcelia* sp. and *Exorista* sp. parasitize larvae and pupae of insect pests (Sajap *et al.*, 1997). The tachinids, being less host specific than hymenopteran parasitoids (Kalshoven, 1981), are likely to parasitize *S. helicina* too.

REMARKS: Hampson (1894) though considered *Speiredonia helicina* Hubner, 1831 a synonym of

Spirama retorta (Clerck, 1764) but remarked 'The *helicina* form is more brightly coloured; female with the ochreous submarginal line of hind wing crenulate'. Presently, *helicina* is treated as a valid species on the basis of these characters and other differences (Kyoung-Sik *et al*., 2006; Gurule *et al*., 2010; Gurule & Nikam, 2011; Sivasankaran *et al*., 2012; Sivasankaran & Ignacimuthu, 2014; Paul *et al*., 2017; Sivasankaran *et al*., 2017 and others) and the same has been followed here.

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Research Article

Elucidating the effect of super oxide dismutase and photosynthetic rate of rice crop variety Pant Dhan 4

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ABSTRACT

A field experiment was carried out during *Kharif* season of 2010 and 2011 to study the effect of different nutrients treatments on the productivity of rice. Application of NPK with FYM and Zn proved to be superior in recording the highest Photosynthetic rate and Super Oxide Dismutase. Although fertilizers are important for enhancing rice production but excess use of fertilizer cause deterioration of soil quality which ultimately affect crop productivity so it is required to investigate the physiological aspects of rice plant under integrated nutrients. When imbalanced fertilizers doses are given to the rice-wheat cropping system, they showed a considerable decline in crop productivity and soil fertility.
Keywords: *Rice, NPK, FYM, Photosynthetic rate and Super Oxide Dismutase.*

INTRODUCTION

In India, rice occupies an area of 44 million hectare with an average production of 90 million tones with productivity of 2.0 tons per hectare. Demand for rice is growing every year and it is estimated that in 2025 the requirement would be 140 million tons. India has to raise its rice productivity by 3 per cent per annum to meet future food requirements (Thiyagarajan and Selvaraju, 2001). Although in India the area is decreased by 43.97 million hectare but the production elevated to100 million tones (FAO, 2012). Ninety percent of total world's rice is grown and consumed in south and Southeast Asia, where the normal consumption of rice ranges 300-800gm per day per person (Virk and Barry, 2009). After green revolution consumption of chemical fertilizers namely nitrogen (N), phosphorus (P) and potash (K) is also increased. Faulty use of fertilizers is one of the reasons for problems of soil salinity and alkalinity in agricultural regions of India. There is a proposed level of fertilizer for each crop and soil, which is known as the optimum level (Kundu and Vashist, 1991).Use of fertilizer beyond the optimum level creates imbalance which may causes environmental problems. Green revolution has brought serious ecological problems. Farmers are increasingly complaining of depleting fertility of soils, soil salinity and alkalinity and problems of ground water pollution this could be due to inefficient use of fertilizers (Sharma, 1993).

The application of essential plant nutrients particularly macro and micronutrients in optimum quantity and right proportion through correct methods and time of application is the key to increased and sustained crop production. As the requirement of fertilizer use varies from state to state and area and area therefore it is important to recognize fertilizer use behavior and role of factor influencing fertilizer consumption at state as well as national level (Jaga and Patel, 2012). Increased use of chemical fertilizers elevated the rice production and biomass. In the recent years, crop productivity has stagnated or decreased in spite of consumption of increased rate of chemical fertilizers (Apon *et al.*, 2018). Application of fertilizer support growth and development of rice as NPK are the macro nutrient required by the plant. Micronutrient like zinc helps the plant to protect from disease. Organic fertilizer improved the vegetative growth. Use of organic and inorganic fertilizer gave a significant effect on plant height and leaf area index. This result assisted by (Uwah *et al.* 2014). The wider leaves will support the arrest of more sunlight better photosynthesis. The more sunlight is absorbed, the more photosynthate generated (Duy *et al.* 2004). Photosynthesis is very crucial in the process of growth and development of plants. Photosynthesis plays a key role in the vegetative growth as well as generative phase in flowering, seed filling and postharvest quality (Pangaribuan, *et al.* 2018). Enzymes are very important to the existence of life itself. Enzymes are utilized by the plant for multi-component defense system and are implied in defense reactions of plants against pathogens and different types of stress factors. Various physiological and biochemical

processes such as cell growth and expansion (Lin and Kao, 1999), differentiation and development, auxin catabolism (Mansouri *et al.*, 1999), lignifications (Sitbon *et al.*, 1999), as well as abiotic and biotic stress responses are performed by Peroxidases (Medina *et al.*, 1999).

MATERIALS AND METHODS

The investigation was done during *Kharif* season of 2012 at Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture & Technology, Pantnagar (U.S. Nagar), Uttarakhand, India. The study was performed on rice crop variety Pant Dhan 4 which was provided with different fertilizer combinations of N, P, K, Zn, FYM namely. Treatment combination constitute of T_1(control), T_2(N_{120}), T_3(N_{120} + P_{40}), T_4(P_{40} + K_{40}),T_5(N_{120} + K_{40}), T_6 (N_{120} + P_{40} + K_{40}), T_7 (N_{120} + P_{40} + K_{40} + Znf),T_8(N_{120} + P_{40} + K_{40} + FYM), T_9 (N_{180} + P_{80} + K_{40} + Znf + FYM), T_{10} (N_{180} + P_{80} + K + Znf + FYM), T_{11}(N_{150} + P_{40} + K_{40}), T_{12} (N_{180} + P_{80} + K_{40} + Znf), T_{13} (N_{180} + P_{80} + Znf), T_{14}{N_{120} + P_{40} + K_{40} (DAP)}.

Half of the nitrogen (1/4 in 150 and 180 Kg N ha^{-1} treatments) and total quantities of Phosphorous and Potash were applied just before transplanting on drained puddle surface and incorporated into top 15 cm. soil manually with the help of spade. The remaining quantity of nitrogen was top dressed in two equal installments in T_1 to T_9 at active tillering and 5-7 days before panicle initiation stage. In T_{10} to T_{12} nitrogen was top dressed at active tillering, 5-7 days before panicle initiation and at flowering stages. The FYM (5 t ha^{-1} on dry weight basis) was applied and incorporated as per the treatment one month before transplanting. The foliar zinc was sprayed 10 to 20 days after transplanting both the year. Two days after transplanting Machete 50 EC (Butachlor at 1.5 Kg ha^{-1}) was sprayed in the field and later one manual weeding was done to keep experiment weed free. For each replication three plants were randomly selected for observations. Observations were recorded on per plot basis. The method of recording observations on various traits is given below.

Photosynthetic rate

Photosynthesis (μmol CO_2 m^{-2} s^{-1}), was determined with the help of portable CO_2 gas analyzer (CID Inc. USA). It was measured in an open system in which instrument takes reference CO_2 from atmosphere. The air flow rate, response time and added interval time were 0.4 LPM, 15 S and 20 s, respectively. The area of window of leaf chamber (broad rectangular) was 11 cm^2. Other system set up values used were those which are already present in the memory of instruments. The time of measurement was kept constant. Photosynthetic rate and stomatal conductance were assessed on intact leaves. All observations were taken in full sun light and data were taken in triplicates for each plant to get the mean value.

SOD activity

Total SOD activity was determined by measuring its ability to inhibit the photochemical reduction of Nitrobluetetrazoliumchloride (NBT), as described by (Giannopolitis and Ries, 1977).

Reagents

1. Enzyme extract: Leaf sample of 0.2 g was homogenized in mortar & pestle with 4ml of ice cold extraction buffer (100mM phosphate buffer ofpH 7.0). Filter through muslin cloth and centrifuge at 16,000 rpm for 15 min and supernatant was used as enzyme extract.
2. Potassium phosphate buffer: Buffer was prepared by dissolving 1.644 g KH_2PO_4 (acid solution) in 100 ml distilled water and 1.008 g K_2HPO_4(base solution) in 100 ml distilled water. Then, a buffer solution was prepared by the mixing of these two solutions. The buffer solution was maintained to pH 7.0 by the help of above mentioned acid and base solutions.
3. Take 1.5 ml reaction mixture contain:-

   50 mM phosphate buffer (pH 7.8)

   0.1 µM EDTA

   13 mM methionine

   75 µM NBT

   2 µM riboflavin

In the tubes take 1.5 ml reaction mixture with 50 µl enzyme extract. Tubes are shaken well and illuminated with two 20 watt fluorescent tubes. The reaction was let to proceed for 15 min. after which the tubes were covered with a black cloth and the lights were switched off. The reaction mixture was allowed to record at absorbance of 560 nm. One unit of SOD activity (U) was defined as the amount of enzyme required to cause 50% inhibition reduction of nitrobluetetrazolium chloride (NBT), as described by **(**Giannopolitis and Ries, 1977).

RESULT AND DISCUSSEN

Photosynthetic rate

Photosynthetic rate was recorded at flowering stage during the planting year 2012 data presented on Table 1.Showed that N_{180} P_{80} +Znf(10.43) were found maximum value of photosynthetic rate however least value of photosynthetic rate was recorded by the control (7.73). Statistical analysis of the data on photosynthetic rate during 2012 at PK, N_{180} P_{80} K+Znf+FYM, N_{180} P_{80} K+Znf, N_{180} P_{80} +Znf and NPK (DAP) was recorded significantly different from control while rest of the treatment was found non significantly different from control. N_{180} P_{80} +Znf were observed maximum photosynthetic rate which was significantly different from all the treatment

exceptN_{180} P_{80} K+Znf+FYM, N_{180} P_{80} K+Znf and NPK (DAP). Control showed minimum value of photosynthetic rate.

Data presented showed that increment in photosynthetic rate was 25.90% for 2012 in comparison to control. Deficiencies of N, P or K decreased the photosynthetic rate, yield components and paddy yields. Photosynthetic rate at an ambient CO2 concentration of350 µL L-1 increased with increases in leaf nitrogen content in all varieties examined. There was a close linear correlation between leaf nitrogen content and the photosynthetic rate for each individual cultivar (Hirshawa *et al.*, 2010).

Table 1. Effect of different nutrients on photosynthetic rate andSOD activity of rice variety Pant Dhan 4 in *kharif* 2012.

S.No.	Treatments	Photosynthetic rate	SOD activity in U/gm
T_1	Control	7.73±0.30	476.26±0.001
T_2	N	7.70±0.18	494.97±0.001
T_3	NP	8.38±0.13	505.26±0.097
T_4	PK	9.23±0.22	511.81±0.0011
T_5	NK	8.78±0.39	512.75±0.001
T_6	NPK	8.80±0.36	528.65±0.089
T_7	NPK+Zn	8.38±0.33	540.82±0.85
T_8	NPK+FYM	8.45±0.13	524.91±0.001
T_9	NPK+Znf+FYM	8.83±0.14	521.17±0.001
T_{10}	N_{180} P_{80} K+Znf+FYM	9.50±0.91	566.08±0.097
T_{11}	N_{150} PK	8.83±0.11	544.91±0.0011
T_{12}	N_{180} P_{80} K+Znf	9.93±0.73	571.70±0.001
T_{13}	N_{180} P_{80} +Znf	10.43±0.53	539.88±0.089
T_{14}	NPK (DAP)	10.30±0.43	561.40±0.085
	S.Em.±	0.41	12.91
	CD at 5%	1.18	36.93

Super Oxide Dismutase activity

SOD activity was recorded at flowering stage during the planting year 2012 data presented on Table 1. N_{180} P_{80} K+Znf(571.70 U/gm)showed maximum value of SOD activity whereas the least value of SOD activity was recorded by the control (476.26 U/gm).

Statistical analysis of the data on SOD activity during 2012 NPK, NPK+Zn, NPK+FYM, NPK+Znf+FYM,N_{180} P_{80} K+Znf+FYM, N_{180} P_{80} K+Znf, N_{180} P_{80} +Znf andNPK(DAP)was foundsignificantly different from control whileN, NP, PK, NK,and N_{150} PKwas found non significantly different from control. N_{180} P_{80} +Znf was observed maximum SOD activity which was significantly different from all the treatments except NP,PK, NK, NPK, NPK+Zn, NPK+FYM, NPK+Znf+FYM, N_{180} P_{80} K+Znf+FYM, N_{180} P_{80} K+Znf and NPK (DAP) is showing minimum value of SOD activity.

The data presented showed that the increment in SOD activity was 16.69% and decreased 7.77% in comparison to control. N_{180} P_{80} K+Znf was showed the maximum value of SOD which reveals the fact that integrated supply of nutrient is important for the increment of SOD activity SOD is one of the protective enzyme active oxygen scavenging enzyme system while clear biological oxygen free radicals in vivo within senescent leaves of plants, the soluble protein which is mainly RuBisCO play a role in plant metabolic activity, which serves as a key enzyme of the photosynthesis contributed to plant fixed CO_2 before leaf senescence. The results obtained the effect of organic fertilizers along with chemical fertilizer with organic fertilizers and recommended dose of NPK on leaf super oxide dismutase (SOD) activity in rice is increased. Half dose of CPMR+ RDF, CPMR organic fertilizer and RDF show results at equal with each other out of all the treatment and better than CM(Cow Manure), CMR(Cow Manure Rice Straw husk), PM(Poultry Manure) and PMR (Poultry Manure, Rice Straw and Husk) in both the years and even in pooled means (Siavoshi and Laware 2013). From the above results it may be concluded that N_{180} P_{80} K+Znf+FYM was observed as the best treatment for all the parameter as Zn is an essential micronutrient and FYM helps in slow release of nitrogen, increase water holding capacity of soil it also works as soil conditioner, whereas when any one of the nutrient is missing it negatively affect the physiology of rice plant. NPK+Znf+FYM, was showed non-significant difference with N_{180} P_{80} K+Znf+FYM which reveal the fact that NPK+Znf+FYM can also be used to reduce soil pollution.

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Research Article

Relative efficacy of certain insecticides against mustard aphid in mustard ecosystem

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ABSTRACT

Studies on the efficacy of eight insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) on *Brassica juncea* cv. Varuna as foliar spray were carried out at Norman E. Borlaug Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar (India) during *Rabi* season of 2018-19. Studies revealed that after third and seventh days of spray, Dimethoate 30 EC, Thiamethoxam 25 WG and Imidacloprid 17.8 SL proved most effective against mustard aphid. The maximum seed yield of 21.69 q/ha was recorded in thiamethoxam, which remained on par with imidacloprid (21.43 q/ha) and dimethoate (20.69 q/ha). The lowest seed yield was obtained from untreated plots (10.44 q/ha).

Keywords: *Mustard, bio-efficacy, insecticides, yield, Lipaphis erysimi*

INTRODUCTION

Rapeseed-mustard is a major oilseed crop next to soybean in terms of production and ranked first in terms of oil yield among all oilseed crops in India. Its grown on an area of about 6.4 m ha with a production of 8.02 Mt and yield is 1262 kg ha-1. It has an oil content ranging from 35 to 45%. It is planted on more than 80% of oilseeds. Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana and Gujarat are the major producing states for rapeseed-mustard accounting for more than 70% of the total area in the country. Even after the availability of better production technique mustard crop is unable to give promising yield in the country. This is because mustard crop suffer heavy loss in yield due to various biotic and abiotic stress. Among the biotic factors, insect-pests are one of the most important constraints in reducing the yield (Patel and Singh, 2017). Out of many insect pests, *Lipaphis erysimi* is considered key pest which causes considerable yield losses. Both nymph and adult suck the cell sap from various tender parts of plant like leaves, inflorescence, soft stem and pods and cause economic damage. Due to heavy infestation of mustard aphid, the symptoms of yellowing, curling drying of leaves appear, resulting in development of feeble and small seeds in the pods. It also reduces the photosynthetic rate and secretes the honeydew which is responsible for sooty mould growth.(Patel *et al.*, 2017). Heavy infestation of aphid depend upon favorable weather parameters, therefore monitoring is necessary throughout the year for managing the pest. Many controlling measures are adopted to manage the mustard aphid population below economic injury level like chemical, mechanical, physical, cultural, host plant resistance and biological control. Among these, at severe attack, the chemical control is very important and provides significantly control. Therefore, the present study was undertaken to evaluate the efficacy of certain insecticides against *L. erysimi* Kalt.

MATERIAL AND METHODS

A field experiment was laid out in randomized block design (RBD) to study the efficacy of certain insecticides against mustard aphid on mustard crop during *Rabi* season, 2018-19 at Norman E. Borlaug Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar (India) with nine treatments viz., Fipronil 5 SC, Thiamethoxam 25 WG, Imidacloprid 17.8 SL, Acetamiprid 20 SP, Acephate 75 SP, Dimethoate 30 EC, Oxy-demeton methyl 25 EC, Clothianidine 50 WDP and untreated control and replicated three times. The crop variety Varuna was sown on 28th October with plot size of 4.2m x 3m and distance between row to row and plant to plant was 30cm and 10cm, respectively. The recommended agronomic practices were followed. Foliar spray of different treatments was made in 500 ltr of water/ha. The population of mustard aphid was

recorded from 10 cm CSL (Central shoot length) on 10 randomly selected plants from each plot one day prior and three seven and ten days 10 days after insecticide application. The yield in each treatment was recorded and expressed in q/ha. The data were subjected to the analysis of variance using simple randomized block design (RBD) programme.

RESULTS AND DISCUSSION

The population of *L. erysimi*, on mustard in various treatments were recorded one day before and 3rd, 7th and 10th day after insecticide application during the crop season 2018-19. Before spray, the mean population of *L. erysimi* ranged from 40.67 to 149.0 aphids per 10 cm Central shoot length (Table 1). Subsequent to spray, aphid population was significantly decreased in all the treated plots, while significantly increased in untreated plots. Data recorded on 3rd day after spray, the *L. erysimi* population was the minimum (0.23 aphids) with Dimethoate 30 EC followed by Imidacloprid 17.8 SL (0.73 aphids) while least toxic treatments harboring highest population were Fipronil 5 SC (29.47 aphids) and Clothianidine 50 WDP (2.06 aphid). At 7th day after spray, the aphid population was again recorded minimum (0.00 aphids) with Thiamethoxam 25 WG, Imidacloprid 17.8 SL, Dimethoate 30 EC and Clothianidine 50 WDP. It was then followed by Acetamiprid 20SP (0.23 aphids), Oxy-demeton methyl 25 EC (0.40 aphids) and Acephate 75 SP (0.80 aphids). While least toxic treatments were again Fipronil 5 SC (8.73 aphids).

At 10th day after spray, the aphid population was once again recorded minimum (0.00 aphids) with thiamethoxam 25 WG, Imidacloprid 17.8% SL, Dimethoate 30 EC, Clothianidine 50 WDP, Acetamiprid 20SP, Acephate 75 SP and Oxy-demeton methyl 25 EC. Similarly previous observations, Fipronil 5 SC was once again found to be least effective with high aphid population of 1.17 aphids. The data on yield (q/ha) (Table 1) indicated that under certain insecticidal treatments, it varied significantly from 10.44 to 21.69 q/h. Maximum seed yield (21.69 q/h) was recorded from plots treated with Thiamethoxam 25 WG followed by Imidacloprid 17.8 SL(21.43 q/h). The lowest seed yield (16.62 q/h) was recorded with Fipronil 5 SC.

The order of efficacy of these treatments was Dimethoate 30 EC > thiamethoxam 25 WG> Imidacloprid 17.8 SL > Acetamiprid 20SP > Oxy-demeton methyl 25 EC > Clothianidine 50 WDP > Acephate 75 SP > Fipronil 5 SC respectively. The effectiveness of the aforesaid insecticides against mustard aphid control on mustard crop is in close accordance with the findings of Vekeria and Patel (2000) and Choudhury and Pal (2005). A number of insecticides have been tested on rapeseed- mustard to determine the efficacy against *Lipaphis erysimi* Kalt. A large number of systemic insecticides were found very effective against sucking pest on various fruit, vegetable and field crops. These are imidacloprid, thiamethoxam, acetamiprid, clothianidin, and Dimethoate. Imidacloprid and thiamethoxam were found most effective against *Lipaphis erysimi* in field condition by Rohilla et al. (2004). Prasad and Dey (2006) reported that imidacloprid was significantly superior even after 14 days of treatment. Patel et al. (2017) evaluated seven insecticides in the field against mustard aphid and found that Imidacloprid gives maximum mortality of mustard aphid with highest yield (12.36 q ha-1).

Maurya *et al*., 2018 observed that the thiamethoxam 25% WG @100 g/ha was found most effective treatment in reducing the aphids population followed by acephate 75 SP @ 500g/ha. The pymetrozine 50 WG @ 250 g/ha was recorded less effective. Among conventional insecticides imidadoprid 17.8 SL was found more effective than dimethoate 30% EC and fipronil 5 SC.. The higher yield was obtained from thiamethoxam 25% WG @100 g/ha with (17.15 q/ha) whereas, highest cost benefit ratio is obtained from imidadoprid 17.8 SL @ 150 ml/ha with (1:9.54). Treated with 0.003% the highest mortality were observed 100% (Dimethoate 30 EC, Chlorantraniliprole 18.5 SC, Lambda cyhalothrin 5EC, Imidacloprid 70 WG Cypermethrin 10 EC) followed by 93.33% (Thiamethoxam 25 WG, Fenpyroximate 5 SC), 80% (Acetamiprid 20 SP, Pyriproxyfen 10 EC) and lowest 66.67% mortality recode in treated with Fipronil 5 SC (Hasan *et al*., 2018).

Thus, the present study revealed that among all the tested chemicals Dimethoate 30 EC, Thiamethoxam 25 WG and Imidacloprid 17.8 may be recommended for effective management of mustard aphid, *L. erysimi* in mustard crop. As rapeseed-mustard are consumed as vegetables in some parts of the country and also provides edible oils for humans and cakes for cattle, the application of these insecticides on these crops should be need-based.

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Table 1: Bio-efficacy of insecticides against mustard aphid, *L. erysimi* (Kalt.)

Treatment	Dosages	Aphid Population (Number)				Yield (q/ha)
		Before spray	After spray			
			3DAS	7 DAS	10 DAS	
Fipronil 5 SC	2 ml /liter	70.00	29.47	8.73	1.17	16.62
Thiamethoxam 25 WG	0.25g /liter	61.50	0.90	0.00	0.00	21.69
Imidacloprid 17.8 SL	0.25ml/liter	45.57	0.73	0.00	0.00	21.43
Acetamiprid 20SP	0.15g/liter	40.67	0.93	0.23	0.00	20.24
Acephate 75 SP	1ml/liter	43.50	2.33	0.80	0.00	20.17
Dimethoate 30 EC	1ml/liter	64.33	0.23	0.00	0.00	20.69
Oxy-demeton methyl 25 EC	1ml/liter	84.17	1.77	0.40	0.00	20.41
Clothianidine 50 WDP	0.3 g /liter	149.0	2.06	0.00	0.00	19.35
Control		59.00	84.17	65.73	27.23	10.44
CD at 5%		50.87	43.01	33.22	13.85	5.42
Sem		11.06	9.35	7.22	3.01	1.18
CV		48.35	205.99	257.02	286.36	18.60

DAS: Day after spray

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Research Article

Time of sowing affect the yield attributes, yield and Economics of wheat (*Triticum aestivum* L.)

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ABSTRACT
The field experiment was carried out at KrishiVigyan Kendra, Aurangabad and at farmers' field during rabi seasons of 2013-14 and 2014-15, to response of time of sowing affect the yield attributes, Yield and Economics of wheat (*Triticum aestivum* L.). Experiment was laid out in a completely randomized block design with 4date of sowing i.e5th November, 15th November 25th November, 5thDecemberin a total of five replications duringrabi 2013-14 and 2014-15. Significantly maximum grain yield (44.64 q/ha) recorded with wheat sown at 5th November being at par with 15th November both were significantly more over 25th November and 5th December. 6.13%, 3.70% more grain yield recorded with at 5th November and 15th November produces over sowing of wheat at 25th November and 33.65% and30.59% more grain yield over 5th December, respectively. Sowing of wheat at 5th November produced more straw yield (52.90q/ha) being at par with 15th November and they were significantly more over 25th November and 5th December. Straw yield recorded 8.49%, 7.51% more with at 5th November and 15th November produces more straw yield over 25th November and 15.96% and14.91% more straw yield over 5th December Sowing of wheat. Significantly highest B-C ratio was also recorded with 5thNovember and statically at par with 15th November over 25th November and 5th December. Highest return 6.13 and 3.71% & by 33.65% & 30.60%, respectively higher returns by were recorded when wheat sown at 5th November and 15th November over 25th November and 5th December respectively.
Keywords: Terminal heat stress, wheat, Time of sowing

INTRODUCTION

Wheat is one of the most staple foods of the humanity (Meena *et al*., 2013). Its area and productivity is increasing rapidly adopting across the globe, due to its wider adaptability sustainability under divers agro climatic conditions (Kumar *et al*., 2014). However, considerable portion of the wheat grown in South Asia is considered to be affected by heat stress, of which the majority is present in India (Joshi *et al*., 2007a). Joshi *et al*., 2007a reported that terminal heat stress is a major reason of yield decline in wheat due to delayed planting in India. Singh *et al*., 2008 also state that selection of suitable crop varieties according to the agro climatic conditions may play crucial role in realizing the optimum production of any crop commodity. The most heat-stressed locations of South Asia are the Eastern Gangetic Plains (EGP), central and peninsular India, whereas heat stress is considered moderate in north western parts of the Indio-Gangetic Plains (IGP) (Joshi *et al*., 2007b). Late planting of wheat suffers drastic yield losses which may exceed to 40-50%. Global climate models reported that increase in mean ambient temperature between 1.8 and 5.8^{o}C) by end of this century (IPCC, 2007. Grain yield was negatively related to the thermal time accumulated above the base temperature of 310C (Mian*et al*., 2007). High temperature above 32 ^{0}C has been reported reducing grain yield and grain weight (Wardlaw*et al*., 2002). Shriveled small grains are produced and different yield associated traits such as tillering, grain weight and grains numbers/spike are reduced. Using this factor (3–4 % loss per 10C above 15–20 ^{0}C), it can be calculated that most commercially sown wheat cultivars in India would lose approximately 50 % of their yield potential when exposed to 32–38^{0}C temperature at the crucial grain formation stage. The experiment was conducted

at the at KrishiVigyan Kendra, Aurangabad and farmers of Aurangabad district during the years *rabi* 2013-14 and 2014-15. By the late sowing the vaieties was given high temperature stress during grain filling stage in comparison to timely sown condition.

MATERIALS AND METHOD

The field experiment was conducted at KrishiVigyan Kendra and farmers' field in Aurangabad district of Bihar during the two consecutive rabi seasons of 2013-14 and 2014-15. The experimental site was allocated at Aurangabad district at 332'above mean sea level and $24^0.50'$ N and $84^0.70'$ E. The maximum temperature remained above 35.60°C and 35.97°C during 2013-14 and 2014-15, respectively. At crop period total rainfall received was 10.77 and 13.25 mm during 2013-14 and 2014-15, respectively The soil was clay-loam having normal soil reaction (pH 7.5), low in organic carbon (0.51%) and available nitrogen (205.7 kg/ha), and medium in available phosphorus (19.3 kg/ha) and available potassium (198.5 kg/ha). The experiment was laid out in completely randomized block design with 5 replications comprising of 4 date of sowing i.e. 5^{th}November, 15^{th} November 25^{th}November ,5^{th} December . In experimental plots, wheat was established by with zero-till drill (ZTD),. The wheat variety HD-2733was tested in different dates of sowing. To allow drill to place seeds at a uniform distance and proper depth the fields were leveled with leveler at the time of sowing of all the replications. Before sowing with zero-till drill the experimental plots meant for zero-till drill (ZTD) sowing were subjected to two ploughing followed by harrowing and planking (ZTD).Experimental field was fertilized at the rate of 120:60:40 kg NPK/ha. Nitrogen was applied in three splits (1/2dose of N at basal rest1/2dose each equal at Ist irrigation and 2^{nd} irrigation), while the entire P_2O_5 and K_2O were applied as basal application. Pendimethalin was sprayed within 1days after sowing, by knap-sack sprayer using 800 litres/ha water in all treatment plots in all replications. Metsalfuron @ 33g/ha as Post-emergence herbicides was applied with knap-sack sprayer fitted with flat-fan nozzle using 500 l/ha of water at 25-30 days after sowing (DAS) in all treatment plots in each replications. The data on plant height, number of tillers, crop biomass and number of grains/spike were recorded. The crop was harvested manually in the second week of April. Variable cost of cultivation and gross returns were calculated on the basis of existing price of the inputs and outputs.

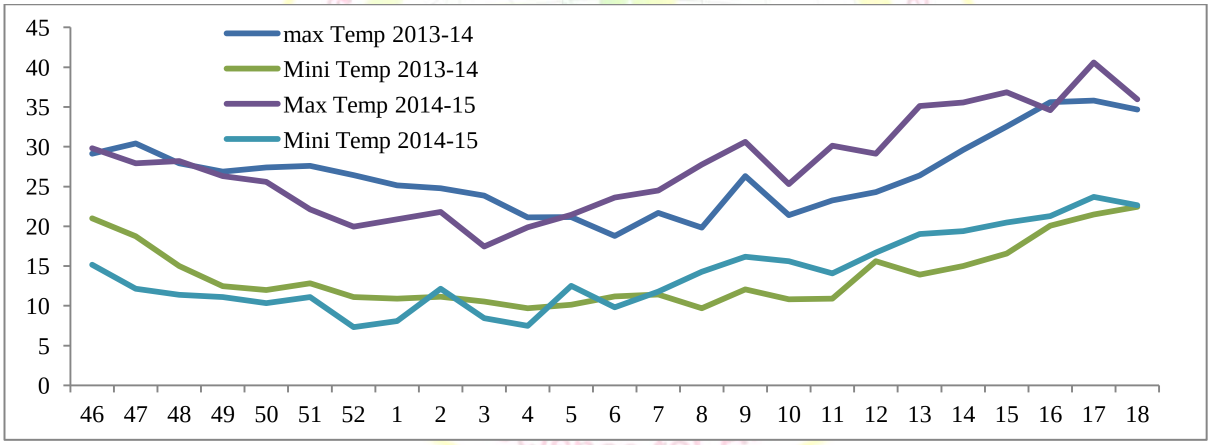

Fig1: Maximum and Minimum Temperature during crop period 2013-14 and 2014-15

RESULTS AND DISCUSSION

Number of effective tillers/m^2, spike length, grains/spike and test-weight was significantly influenced by different date of sowing. Number of effective tillers/m^2 at harvest stage recorded maximum with wheat sown at5^{th} November being at par with 15^{th} November both were significantly higher over 25^{th} November and 5^{th} December. Spike length was recorded significantly higher with wheat sown at 5^{th} November over other treatment. Number of grain significantly influenced by date of sowing maximum number of grain/spike was recorded with when wheat was sown at 5^{th} November over 15^{th} November, 25^{th} November and 5^{th} December. 1000 grain weight was also significantly influenced by date of sowing.Maximum1000grain weight recorded with wheat sown at 5^{th} November being at par with 15^{th} November they were significantly higher over 25^{th} November and 5^{th} December (Table1).

Table1: Effect of date of sowing on yield and yield attributes and yield on wheat (Pooled data of two years)

Treatment	No. of effective tillers/ m^2	Length of Spike (cm)	No of grain/ spike	1000 grain Weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
T_1- 5 November	334.20	9.54	48.40	44.56	44.64	52.90
T_2 –15 November	318.20	9.13	44.80	45.06	43.62	52.42
T_3 –25 November	276.40	8.79	43.80	43.80	42.06	48.76
T_4–5 December	235.00	8.25	40.20	41.50	33.40	45.62
LSD (P=0.05)	22.97	0.37	2.98	0.91	2.32	2.85

Sowing of wheat at 5th November produce significantly maximum grain yield (44.64 q/ha) being at par with15th November both were significantly more over 25th November and 5th December. Early sowing of wheat at 5th November and 15th November produced significantly 6.13%, 3.70% more grain yield over 25th November and 33.65% and 30.59% more grain yield over 5th December, respectively. Straw yield (52.90q/ha) recorded maximum with5th November being at par with 15th November both were significantly more over 25th November and 5th December. Sowing of wheat at 5th November and 15th November produces 8.49%, 7.51% more straw yield over 25th November and 15.96% and14.91% more straw yield over 5th December, respectively(Table1).Similar findings was also reported byDwivedi*et al*. 2015.

The benefit accrued was more in wheat sowing at 5th November and statically at par with 15th November over 25th November and 5th December.Net return (Rs 39228/ha) recorded significantly higher with 5th November and statically at par with 15th November over 25th November and 5th December. The B-C ratio also recorded significantly higher with 5thNovember and statically at par with 15th November over 25th November and 5th December. The higher returns by 6.13 and 3.71% & by 33.65% &30.60%, respectively were recorded when wheat sown at 5th November and 15th November than 25th November and 5th December(Table 2).

Table2: Effect of date of sowing on economics on wheat (Pooled data of two years)

Treatment	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
T_1- 5 November	25500	64,728	39,228	2.54
T_2 –15 November	25500	63,249	37,749	2.48
T_3 –25 November	25500	60,987	35,487	2.39
T_4–5 December	25500	48,430	22,930	1.90
LSD (P=0.05)	-	3,367	3,367	0.13

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Research Article

Backyard poultry farming for meat and egg production: rural enterprise

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ABSTRACT

Twenty farmers selected from each village for 6 villages of the district and skill based training on various aspects of backyard poultry farming. Participants enriched with sound knowledge were distributed with 25 Vanaraja & Grampriya chicks per person. The records of mean body weight of Grampriya and Vanaraja at different week interval. The body weight of crosses differ significantly ($p < 0.05$) after 4th week of age from their parents. The body weights of crosses were significantly ($p < 0.05$) higher than Hazra (Desi) birds and nearly similar to Vanaraja birds at different period of age attaining the sexual maturity in different groups of poultry birds. Vanaraja matures at the age of 141.62 days, Hazra (Desi) bird at 186.47 days and Grampriya at 158.32 days. The pullet egg weight of Vanaraja, Hazra (Desi) and Grampriya were 38.75, 30.82 and 34.94 g, egg weight at 40 weeks of age were 55.87, 42.89 and 51.26 g and increase in egg weight were 17.12, 12.07 and 15.42 g respectively. The hatchability percentages were 87.56%, 89.36% and 85.72% on fertile egg set and 68.23%, 68.92% and 64.74% on total egg set basis respectively in Vanaraja, Grampriya and local desi birds.
Keywords: *Sexual maturity, Vanaraja, Grampriya , Desi and egg weight*

INTRODUCTION

Indian agriculture sector contributes 28 per cent to the gross domestic production income (GDP) in India, among which 17% of income from poultry. Today India is the third largest egg and fifth largest in broiler production in the world. The Indian poultry industry growth rate is 8 to 10% for eggs and 15 to 20% for broiler meat production (Shrivastava, A.K., 2011). In India per capita availability of egg and meat are 45 and 2.00 kg respectively against the recommended level of 180 eggs and 9.00 kg of meat by Indian council of medical research (Niranjan *et al*, 2008). To meet the growing demands of the population and to improve the per capita consumption among the rural / tribal people, All India Coordinated Research Project on poultry breeding at Bihar Veterinary college Patna center, funded by Indian Council of Agricultural Research, New Delhi have developed improved chicken varieties suitable for free range/ backyard farming for rural and schedule areas. The population of land less Jehanabad District, Bihar is predominantly schedule tribal in nature. Non-vegetarian food pattern is huge demand for meat and egg but the production is poor due to rearing of livestock is traditional method. On the basis need,

high production potential poultry bird, Vanaraja & Grampryia, has been introduced and popularized as a sustainable livelihood for rural area. Presently, the backyard poultry farmers (9345) and poultry population (96,262), duck (4619), quail (250) at Jehanabad district (survey, 2012) . Growth and production traits of a bird indicate in respect to that of specific environment, genetic constitution and adaptation (Ahmed and Singh 2007).

MERIALS AND METHODS

Selection of 6 villages in the Jehanabad district and each village 20 farmers were selected on the basis of skill based trained of backyard poultry farming. Participants enriched with sound knowledge were distributed with 25 Vanaraja & Grampriya chicks per person free of cost under front line demonstration mandate of KVK, Jehanabad. Vanaraja & Grampriya chicks for distribution among farming community were procured from Poultry. Division (AICRP), Bihar Veterinary College, Patna, Bihar Agriculture University, Sabour, Bhagalpur. Periodical visits were made to beneficiaries units for health check-up as well as to collect information on growth performance and egg production potential of Vanaraja & Grampriya chicks breed. All chicks were brooded up to three months of age under deep litter system and thereafter transfer in villages. Chick starter ration along with kitchen waste materials were provided to the chick up

to 6 months of age. Subsequently, the grower ration during growing and layer ration during laying periods were provided. The experiment was conducted at Jehanabad which is located between 25^0-$25^0$15' North latitude to 84^0 30'- 85^0 - 15' East longitude. It experiences subtropical climate, characterized by hot summer from March to May and well distributed rain fall during southwest monsoon from June to October.

All the chicks were immunized against Ranikhet disease by using F1 and Lasota strain, Gumboro (IBD) disease vaccine using intermediate strain & other vaccination and deworming schedule were followed by 72 weeks of ages (Chauhan and Roy, 2003). The weekly body weights gain and mortality pattern of chicks were recorded. Relative growth rate of chicks were assessed based on the weekly body weights. The weight of pullet when first egg lay, pullet egg weight, egg weight at 40 weeks of age and increase in egg weight were recorded. Age of laying first egg, number of eggs lay in 40 weeks and in 72 weeks period were recorded. The data was analyzed as per standard statistical methods described by Snedecor and Cochran (1994). The effect of genetic group on the different growth and production trait were studied.

RESULTS AND DISCUSSION

The mean body weight of Grampriya and Vanaraja at different week interval are presented in table 1. The body weight of crosses differ significantly ($p < 0.05$) after 4^{th} week of age from their parents. The body weights of crosses were significantly ($p < 0.05$) higher than Desi birds and nearly similar to Vanaraja birds at different period of age (table 1). Body weight is the direct reflection of growth, production and reproduction trait of birds. In this present study was found most significantly variation in sexual maturity of different groups of poultry birds. Vanaraja matures at the age of 141.62 days, Desi bird at 186.47 days and Grampriya at 158.32 days. The higher body weight gain and early age of sexual maturity in crosses compare to indigenous birds may be because of genetic inheritance of Vanaraja birds prevailing in crosses.

Egg production and egg weights determine the success of poultry enterprise. The pullet egg weight of Vanaraja, Desi and Grampriya were 38.75 g, 30.82 g & 34.94 g, Egg weight at 40 weeks of age were 55.87g, 42.89 g & 51.26 g and increase in egg weight were 17.12g, 12.07g & 15.42 g, respectively. Egg weight at first lay and at 40 weeks of age was significantly ($p < 0.05$) varied in crosses compare to their parents as shown in table 1. The present study was found varied significantly ($p < 0.05$) among them of egg production at 40 weeks and 72 weeks of age. The excelled performance of crosses might be due to the paternal inheritance from Grampriya birds utilized in developing the crosses. Mortality percentages were found more than that of their parents, in all stage of starter, grower and layer poultry and it was within permissible limit (table 1). Mortality rate was higher in winter, lower in rainy and least during summer season. There was no any specific disease outbreak recorded during the experimental period in the farm. The cross has substantial production capabilities as dual purpose bird suitable for rural and backyard farming in India. Therefore, it is concluded that the cross bred poultry is better than that of rural poultry varieties for suitable of alternative dual purpose variety for backyard poultry farming.

The hatchability percentages were 87.56%, 89.36% and 85.72% on fertile egg set and 68.23%, 68.92% and 64.74% on total egg set basis respectively in Vanaraja, Grampriya and local birds. The mean percent hatchability observed in this study on fertile egg set and total egg set basis was higher than the values observed by Pandian *et al*, (2011) (85.99% and 64.48%) in bantam chicken. The body's weight of F1 cross was higher than that of indigenous poultry during week interval. The excelled performance of crosses might be due to the paternal inheritance from Vanraja utilized in developing the crosses. Body weight is the direct reflection for growth, production and reproduction trait of birds *(*Nirajan *et al*, 2008). The significant effects of genetic group on body weight of chicken were reported by many workers (Mohammed *et al.*, 2005, Chatterjee *et al.*, 2007) similar to the present study. The comparable estimates were reports by (Haunshi *et al.*, 2009) and Niranjan *et al*., *2008*) in Gramapriya birds. The present study were in agreement with earlier report of Jha *et al*., (2012), who reported similar type of growth pattern performance of Desi birds. The lower body weight of local Desi birds was on expected line since indigenous chicken are known to have lighter and compact body weight to escape from the rearing of free range system (Haunshi *et al.*, 2009).

Average age at sexual maturity (ASM) in our finding was 141.62, 186.47 and 158.32 days respectively in Vanaraja, Grampriya and Desi birds. The lower age at sexual maturity in the layer is desirable, which may lead to the increase laying period and improving the egg production. Previously, Haunshi *et al*. (2009) reported that there was comparatively higher age of sexual maturity in improved varieties Gramapriya (179.50 days) and Vanaraja birds (197.70 days), which developed for backyard farming. In backyard farming reported by Niranjan *et al.* (2008) at 160.89 and 164.79 days attaining sexual maturity of Gramapriya and Vanaraja birds, Whereas comparatively lower age of first lay for Gramapriya birds in intensive (138 days) and extensive (142 days) system of management recorded by Giri and Sahoo (2012).

Table 1: Growth and performance of Vanaraja, Grampriya and Hazra (Desi) of different ages

Age of chicks		Vanaraja (g)	Grampriya (g)	Hazra (Desi)(g)
0 Day		34.28±0.32 [b]	33.61±0.26 [ab]	30.57±0.23 [a]
4 Weeks		146.72±2.14 [b]	139.34±2.23 [ab]	124.85±1.27 [a]
6 Weeks		371.46±1.38 [b]	348.38±1.58 [b]	196.81±2.51 [a]
8 Weeks		498.56±1.82 [b]	478.93±2.42 [b]	276.78±3.24 [a]
12 Weeks		815.76±3.34 [b]	794.36±4.25 [b]	523.25±4.73 [a]
16 Weeks		1236.41±2.95 [b]	1156.24±3.92 [b]	651.36±5.12 [a]
20 Weeks		1572.31±1.87 [b]	1464.52±2.75 [b]	986.74±5.85 [a]
40 Weeks		1835.52±4.65 [b]	1682.28±4.73 [b]	1259.84±6.23 [a]
Age at Sexual maturity (Days)		143.65±1.76 [c]	171.38±1.42 [b]	212.43±1.65 [a]
Egg weight at 40 weeks of age		55.87±2.24 [b]	51.26±2.35 [ab]	42.89±2.37 [a]
Increase in egg weight (g)		17.12	16.32	12.05
No. of eggs laid in 40 weeks period		72.57 ± 3.46 [c]	58.26 ± 3.58 [b]	11.83 ± 3.72 [a]
No. of eggs laid in 72 weeks period		214.52 ± 3.95 [c]	167.48 ± 4.71 [b]	61.83 ± 4.83 [a]
Egg shell color		Dark brown	Brown to light brown	Creamy
Mortality (%)	Starter (0-8 week)	7.54	8.63	6.85
	Grower (9-20 week)	2.61	3.57	2.78
	Layer (21-72 week)	0.95	1.27	0.46
Means bearing same superscript within rows (small letters) did not differ significantly ($P < 0.05$)				

The present study was recorded total eggs produced for crosses birds at 40 weeks and 72 weeks period higher in respect of Niranjan *et al.* (2008), who reported 56.15 and 149.47 eggs respectively in Vanaraja birds. In intensive system production of eggs 93.25 eggs and 78.0 eggs in Gramapriya birds reported by Giri and Sahoo (2012). The value of egg quality obtained in these study were compared to that of Arya *et al.*, (2012) in desi and exotic crosses during backyard farming and in colored broiler sire line under agro climatic condition of Tripura reported by Malik and Singh, (2011).

The overall mortality of all the three group of birds was recorded as shown in table 1. Mortality was mainly found due to bacterial and infection of yolk sac (coryza& colibacillosis) and protozoal (coccidiosis). There was no outbreak or death due to specific diseases was observed during the course of study. These finding were better than the earlier report of Jha *et al.* (2012) who reported 23.12 % mortality in Desi birds under intensive management system. Giri and Sahoo (2012) reported 9.65 % and 24.66 % mortality upto 8 weeks of age in Gramapriya birds under intensive and extensive system of management respectively. Over 50 Farmers adopted the Enterprise, five progressive farmers Mr. Manoj kumar, Mr. Kundan Kumar, Minazul Haq, Nakul kumar and Arbind Kumar respectively from Deora, Nonhi, kako, Jehanabad and Rukunpura villages initially started this enterprise on commercial scale. They could produce 96,500 boilers birds and distributed among these 9345 fellow farmers. Fifty farmers are less practicing for capital intensive, economic returns and livelihood oriented enterprise in the district. Successful farmers have produced about 60,000 boilers birds and they also started of local birds i.e. Vanaraja & Grampriya chicks for eggs production because of easy accessibility of eggs at doorsteps & also start the enterprise. Back yard poultry farming great opportunities of employment generated and commercial farming for rural youth population at village levels. The venture has successfully generated average income from eggs and meat due to desi non -descript bird upgraded by crossbreeding of improved breed. Results concluded that the Vanaraja & Grampriya as compared to Desi birds are characterized by faster growth, more number of bigger sized eggs, thrives well under low input system, resistance to most of the diseases, and requires small space, minimum labour force and investment and aid to self-employment and income generation.

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Research Article

Applications of remote sensing and GIS for watershed characterization and soil loss assessment of tons watershed in Dehradun, Garhwal Himalaya

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ABSTRACT
Watershed characterization is the most important part of watershed management which includes soil loss, soil loss assessment indicates the amount of soil loss or erosion in ton/hectare/ year through applying to Geospatial techniques as Remote sensing and GIS. The agricultural land is being lost by manmade as well natural whereas manmade or anthropogenic factor accelerates erosion of soil. It is a worldwide phenomenon leading to loss of decrease of water table availability for plants, increases runoff from the more impermeable subsoil, and loss of nutrients from the soil. Watershed management and assessment of soil loss are most helpful for planning and batter management in a watershed and planning units. Remote sensing and GIS along with the satellite image-based model approach provides a scientific, quantitative, and applied result. It can compute a consistent outcome of soil erosion and sediment yield for a wide range of areas under all climatic circumstances. Revised Universal Soil Loss Equation (RUSLE) apply to soil loss, which is integrated with Remote Sensing and GIS in Tons watershed lies between 77°56’05” E to 78°01’01” East longitude and 30° 21’05” N to 30°26’51” North latitude, having 97.02 km2 area (9,702 hectares) under the sub-tropical climatic region of Uttarakhand. The present case study based on computational with software and geospatial technologies results come i.e. A = is the computed soil loss per unit area, R = is the rainfall erosivity, K = is the soil erodibility factor, L = is the slope-length factor, C = is the cover and management factor, P = is the support practice factor. The rainfall erosivity (R=87.5 + 0.375 × R), C P is under range 0.006-0.8, Soil Erosion Risk range is slight to High 51.40% and 0.85% total area of the study region. Average annual soil loss ton/ha/year indicated in different land-use classification as lowest soil loss found in River bed (0.17 ton/ha/year) and highest shown in the open forest (56.58 ton/ha/year) in 2016. The study area comes under a low probability zone and partially comes under a moderate and moderate-high zone. The case study can be highly recommended and will help to implementation of management of soil loss and soil conservation practice in the Tons watershed as well as Himalayan regions.
Keywords*: RUSLE, Tons Watershed, Soil Loss, Remote Sensing & GIS, Garhwal Himalaya.*

INTRODUCTION

Soil is a natural form of mineral and organic components, which is different from the elements towards interior depth of soil in morphology, physical elements, chemical elements, structure and biological features. (Jofie, 1936 & Birkeland, 1974, 1999). Natural geological erosion process is the erosion of land and its natural state, even not by anthropogenic activities (Desmet and G. Govers, 1996). Uneven land surfaces are being continually eroded by running water, wind, ice or other geological agents. The eroded materials are then deposited in valleys and alluvial plains. The removal and formation of soil go on simultaneously. The process of soil formation is slow, but that of erosion may vary in its rate and magnitude. However, nature has a balancing between the two. The soil is the most important basic natural resources available for man. It serves as an anchorage for the plants and reservoir for the plant nutrients. The soils are responsible for the agriculture and forestry. It is, therefore, inevitable to use soils systematically to help and upgrade the standard of mankind (Soil and Water Conservation Society, 1993). Present days here has been a rapidly developing role which soil serves as one of the important primary resources.

A thorough knowledge of the soils finds a suitable place in planning for agriculture, forestry and other developments programme. The scientific information about soils is obtained through standard soil survey. Soil survey is an integral part of an effective agricultural research and advisory programme. Much attention and priority is being given for modernization of soil survey methods. Soil erosion over the earth surface is a quite-frequent and well-distributed troubled. Risk level area map is generated to important issue causing of water or wind, Soil erosion model especially indicate and draw attention

to soil coverage by lively green vegetation and residue (Berk Ustun, 2008).

When soil is covered with plants and crops residues, soil erosion is often reduced during heavy rainfall. (N Doidato, 2004). The farmer can play an important role to minimizing soil loss and conserve their agricultural farm himself. After all, it is the farmers who must reduce the level of erosion sediment from their cropland. Soil erosion from runoff by water is often accepted as an inevitable phenomenon that includes agriculture practices on sloping lands (Shown, Frickel *et al.,* 1981 & Gary C, *et al.,*, 1914). The loss by erosion or runoff is not an inescapable practice. The farmer can effectively control erosion, reduce runoff and increase the amount of water on his land through the use of site specific and customized farming systems and management practices. Runoff water is not known to be used for crops, while irrigation and blocked water can be used effectively by plants, which is very important for growing in dry climates. (W.H. Wischmeier and DD Smith, 1965 & 1978).

Soil erosion in agriculture systems is a very important problem to manage. Humus is constituent dirt and biotic components which is called topsoil. If this layer is eroded away by wind and water, then the ground is very unproductive in producing crops. High wind can blow away loose soils from flat or hilly terrain. Water erosion only occurs on slopes and its severity of the slope. In many parts of the world much of the wind erosion occurs in winter when the ground is frozen but the upper most layer of the soil is loose and dry. Water erosion occurs during the spring with the thawing and melting action of the snow. Several terms are used in association with the removal of soil from the land surface. Although there is not complete agreement in the connotations attributed to these terms, the following definitions are employed in this report. Erosion includes a group of processes by which earth materials are entrained and transported across a given surface. Soil loss is that material actually removed from the particular hill slope or hill slope segment (SK Saha, *et al.,*1992). The soil loss may be less than erosion due to on-site deposition in micro-topographic depressions on the hill slope. RUSLE estimates soil loss from a hill slope caused by raindrop impact and overland flow (collectively referred to as "in Terrill" erosion), plus rill erosion (C.C. Truman and J.M. Bradford, 1995). It does not estimate gully or stream-channel erosion.

MATERIALS AND METHODS

The case study has done through primary and secondary data integrated with Remote Sensing and GIS computation, other geospatial technologies, RS-GIS software, SOI Topo map for validation of the study area. All computational algorithmic analysis has been done in IIRS Lab Dehradun. LISS-III Satellite images, Soil data, Rainfall Data etc. collected from secondary sources. Primary data has collected for validation and analysed i.e. soil sample, physiographic survey, agricultural plots visit etc.

Satellite Data Used: Remote Sensing Data; Satellite-IRS-P6, Sensor-LISS-III

LISS-III image	DATE	PATH NO.	ROW NO.
1	15-March,2016	096	049

Software Used

ERDAS Imagine 10.0

ERDAS IMAGINE is a very useful programme for accessing a huge database of geospatial data. It enables us to make decisions on different situations. EEDAS Imagine can capture and tracks specific times and places, and monitor occurred changes. The programme is one of the best solutions, providing tools to create, manage and analyse imagery. It will provide us with high value geospatial information. The programme combines Remote Sensing and GIS techniques, which enable us to manage geospatial data, and extract information that we need.

Arc GIS 10.0

Arc GIS is a Geographic Information System (GIS) for working with maps and geographic information. Software is applied to creating maps, compiling spatial and non-spatial data, to sharing and discovering data, analysing and using maps even spatial and non-spatial information application, DBMS. GIS provides a basic framework for making maps and geographic information available on a web, and even without the web.

ILWIS Version 3.3

The Integrated Land and Water Information System is a PC based GIS, and Remote Sensing Software, developed by ITC up to release 3.3 in 2005.ILWIS comprise a complete package of image processing, spatial analysis and digital mapping. It is easy to learn and use. Also it has full online help, extensive tutorials for the direct use in the courses and 25 case studies of various disciplines

Soil Erosion Risk Assessment Using RUSLE Model

Soil loss is defined as the amount of soil eroded over a given time period in which pure soil loss is experienced. It is expressed in terms of mass per tonne, per hectare and per year (ton / ha / year). (Ton/ha/year) (Kuldeep Pareta & Upasana Pareta, 2012). USLE (Universal Soil Loss Equation) was introduced by Wishmeier and Smith in 1965 after revised this equation called RUSLE and modified as MUSLE version (Wishmeier and Smith, et. al., 1978), present study is based on RUSLE (Revised Universal Soil Loss Equation) to predict annual soil loss from study area. The RUSLE can be expressed as follows:

$$A = R \times K \times L \times S \times C \times P$$

Where,

A = Computed soil loss per unit area.

R = Rainfall erosivity.

K = Soil erodibility factor.
L = Slope-length factor.
C = cover and management factor.
P = support practice factor (assumed to be one)
Rainfall Erosivity (R)

The rainfall erosivity factor is calculated with the help of average annual rainfall of the seven years. The equation of calculating the rainfall erosivity is –

R= 1686+0.329*DEM

R Factor = 87.5 + 0.375 * R (Ram Babu equation for soil Rainfall erosivity)

Soil Erodibility (K)

K represents both susceptibility of soils erosion and the rate of runoff as measured under the standard unit plot conditions. The properties of a soil that influences its erodibility are soil texture, organic matter content and soil permeability (M.P. Tripathi, Panda, S R.K,Pradhan And S Sudhakar, 2002). Based on soil profile study and laboratory analysis, K values for various physiographic soil units were obtained and soil erodibility K factor map is generated.

Slope Length (L)

L factor is representing the effect of slope length on erosion. The length of the slope is the distance from the origin of the flow of land along its flow path to the place of deposition. In this case study LISS-III data by the help of ILWIS software utility button field width across the slope which represents slope length was measured. Homogeneous field areas were delineated and slope length measured of many fields and length was generated (S.K Saha. M Kudrat and SK Bhan, 1990).

Slope Steepness (S)

S factor represents effect of slope steepness on erosion, soil loss increase more rapidly with slope length. The relation of soil loss to gradient is influenced by density of vegetation cover and soil particle size (Dutta. Pradip, 1999). In this case study from CARTOSAT data DEM map was generated from which terrain slope map in percentage was generated.

LS factor is generated from the CARTOSAT DEM with the help of this equation:

LS=pow((flowaccumulation*30/22.1),0.14)* pow (Sin(Slope_rad)/0.09,0.6)

Crop Cover Management and Support Practices (C and P)

The C factor (Crop Cover Management) is used to represent the effect of cropping and management practices in a unit area which associate to erosion rates. This crop cover management is the most frequently used factor for comparing soil erosion effects, which will affect soil conservation planning, average annual soil loss, and that various activities such as crop rotation or other management plans are also included (B Bhusan, K.L Khera. Rajkumar, 2002).

Table 1: Areal extent of Physiographic Units

Physiographic Unit	PH Unit	Area (Sq. Km)	Area (%)
River Bed	R	1.41	1.64
Steep Himalayas Dense Forest	H11	3.44	4.02
Steep Himalayas Open Forest	H12	33.87	39.48
Moderate Sloping open Forest	H22	0.98	1.14
Settlement	S	4.99	2.79
Lower Piedmont (Scrub)	P24	9.73	1.34
Lower Piedmont (Fellow Land)	P25	1.97	2.29
Lower Piedmont (Agriculture)	P23	0.22	0.26
Residual Hill (Dense Forest)	RH1	5.94	6.92
Upper Piedmont (Dense Forest)	P11	1.82	2.12
Upper Piedmont (Scrub)	P14	11.98	13.97
Upper Piedmont (Agriculture)	P13	3.34	3.89
Moderate Sloping (Dense Forest)	H21	15.95	18.59
Moderate Sloping (Agriculture)	H23	0.30	0.35
Steep Sloping (Agriculture)	H13	1.01	1.18
Total		96.97	100.00

Support Practices (P)

P factor (Support Practice) represents the impact of support practices on the average annual erosion rate in ton/ha/year. In this study based on visual interpretation on FCC and field survey showing different management practices were interpreted and delineated. The polygon map was prepared and rasterized and finally the management practice values were assigned based on literature to generate attribute class map showing P value in the area and ultimately P factor map was generated. Different types of maps like LULC map, Physiographic map, slope map and soil map have been prepared by using satellite images and Topo sheet of the study area. Soil mapping needs identification of a number of elements (S.K. Bhattacharya, 2000). The elements which are of major importance for soil survey and land type, drainage pattern and drainage condition, vegetation, land use, slope and relief. The methodology comprises three round approach (Fig. 1);

Study Area

The study area is located in Dehradun district of Uttaranchal. The Tons Watershed is located between

30°19'51.26" to 30°27'57.03 N latitude and 77°53'21" to 78°02'56" E longitude. The area of the watershed is 129.4 km^2.Tons Watershed a part of Dehradun district, Uttarakhand state, India, lies between 77°56'05"E to 78°01'01" East longitude and 30° 21'05"N to 30°26'51"North latitude approximately, covering an area of 97.02 km^2 (9702 hectares). It is a part of Dehradun district, Uttarakhand state, India. The study area is situated in between towards Tons river in the south west, Forest Research Institute and Tapakeshwar, Badshahibagh agricultural area in the east, Bakarna reserved forest in the North East, Batoli Block Sal forest in the North West and Donga Block dense Sal forest in the west. The climate of the area is sub-tropical with mild to hot summer and very cold winter. The annual rainfall of the area is 2051.4 mm. The main landscape viz. mountain and piedmont constitute the area (Fig. 2&3).

There are no alluvial plains in our study area. The northern and north western regions are dominated by mountains; Southern and eastern parts are dominated by piedmont plains, along Darer, Ghulatia and Nimi rivers. The major land uses of the area are cultivation, forest and settlement. It is bound in the north by the Lesser Himalayan range and in the south by the Siwaliks. It forms an asymmetrical synclinal valley. This watershed is occupied by the Asan river which flows north-westwards and joins the Yamuna river. All these physiographic units are extended NW-SE to ENE-WSW. The major drainage present in the area is parallel to sub-parallel, sub-dendritic, trellis, angular, rectangular, intermittent and braided (Fig. 2).

RESULTS AND DISCUSSION

Physiographic Characteristics

In the physiographic map, physiographic units are divided into sixteen parts. These units are divided on the basis of slope steepness. The watershed falls under the hills and river terraces. Each unit has its own characteristics on the basis of soil, vegetation, and slope. The total area of the physiographic unit is 97.02sq. km and each unit have a different area. In physiographic map different soil attributes are examined like as; Soil depth, Texture, Drainage, Slope, Coarse fragment, and Erosion (SK Saha et al., 1992). The texture of the watershed varies from one map unit to another such as; the textures of the Hills are coarse sandy loam and silt loam. River terraces are silt loam and loam. The soil depth in the upper hills is extremely shallow to very shallow. In agriculture field, it is moderately deep, deep, and very deep. In the agriculture field, the coarse fragment is very slight and in upper hills, the coarse fragment is very severe (SK Saha et al., 1992).In watershed drainage are excessive and well due to slope steepness moreover, erosion is very high in the hills where land cover is very less, moderate in the upper river terraces, and slight in the agricultural fields (Table 2 & 3).

Table 2: Soil Characteristics of Various Physiographic-Soil Units

Physiographic Units	Slope (%)	Drainage	Coarse fragments (%)	Texture	erosion
H1	15-25	Excessive	40-75	Sl	e1/e2
H2	15-25	Excessive	40-75	Sl	e2/e3
H3	60-70	Excessive	40-75	Sl	e2
UP1	10-15	well	15-40	Sil	e1
UP2	7-10	Excessive	15-40	Sl	e2/e3
UP3	5-7	Moderate well	<15	L	e1
MP1	5-8	well	<15	Sil	e2
MP2	1-2	well	<15	Sil	e1
MP3	2-3	well	<15	Sil	e1
MP4	5-8	well	<15	L	e1
LP1	5-8	well	<15	Sil	E2/e3
LP2	3-5	well	<15	Sil	e1
LP3	1-2	well	<15	Sil	e1
RH	7-10	well	<15	Sil	e1
RT	1-2	Well	<15	sl	e1
River	-	-	-	-	-

Land use Land Cover

The major land use land cover of the study area is forest, agriculture, scrub land, and riverbed. The forest comprises dense forest, degraded forest. The scrub comprises dense scrub and open scrub. In agricultural field terrace and bonding practices are prominent (Table 3 & Fig. 5).

Rainfall Erosivity Factor (R)

It is calculated the average rainfall of the twenty-five years. The average rainfall of the twenty-five year is 2051.4mm. The equation is calculated the rainfall erosivity;

R= 1686+0.329*DEM (cell size of raster image)

R_Factor = 87.5 + 0.375 * R (Ram Babu equation for Rainfall erosivity)

Rainfall erosivity computed by Ram Babu (1978) which is specially favourable for Indian region. In study region, results observed rainfall erosivity range value varies *R*-value from 791.801 to 988.831 (Fig. 8). Rainfall intensity and slope are co-related for soil loss although duration of rainfall is most significance to erosion of soil (KG Renard, and JR Freimund, 1994). Runoff from agricultural lands are usually higher spring month when the soils are saturated, according to observed range of value is moderate and partial patches are under high erosivity of rainfall in the study area. Maximum area of the study region is under the moderate R factor, whereas intensity of rainfall not high which of area is under range of low and moderate.

Soil Erodibility (K) Factor

The K factor is an expression of the inherent erodibility of the soil or surface material at a particular site under standard experimental conditions (JK Mitchell *et al.*, 1983) The value of *K* is a function of the particle-size distribution, organic-matter content, structure, and permeability of the soil or surface material (J.V. Bonta and W.R. Hamon, 1980). For undisturbed soils, values of *K* are often available from soil surveys conducted by the National Resource Conservation Service (NRCS) for disturbed soils, the Nomograph equations embedded within the RUSLE program are used to compute appropriate erodibility values (W.R. Curtis and Superfesky, 1977). Soil texture is the major factor to affecting *K* factor, but structure, organic matter, permeability also contributes. Soil erodibility is computed from map of soil properties. There are thirty soil sample were collected from the field (Table 2).

Table 3: Areal extent of Land Use Land Cover

LULC Classes	Area(Sq. Km)	Area (%)
Settlement	5.152790106	5.310783
Dense Forest	19.14404139	19.73103
Open Scrub	1.312710808	1.352961
River Bed	1.411090578	1.454357
Fellow Land	1.968439706	2.028795
Dense Scrub	21.72384443	22.38993
Agriculture	4.858516631	5.007487
Open Forest	41.45361252	42.72465
Total	97.02504616	100

Table 4: Distribution of Slope in Study Area

Slope (%)	Area(h)	Area (%)
<2	463.35	3.668
2-8	3536.79	27.999
8-15	2773.48	21.956
15-30	3329.53	26.358
30-50	1757.99	13.917
50-70	454.67	3.599
>70	315.92	2.501
Total	12631.7	100

Table 5: C and P factor

UNIT	C Factor	P Factor
Orchards	0.05	0.5
Forest	0.006	0.5
Fallow	-	-
Scrub	0.05	0.5
Settlement	-	-
Riverbed	-	-
Agriculture	0.5	0.8

Table 6: Extent of Soil Erosion Risk Class in Tons Watershed

Classes	Soil Loss (t/ha/yr)	Area (Sq. Km)	Area (%)
Slight	0-10	49.7439	51.40
Moderate	10-25	4.7151	4.87
Moderate High	25-50	14.9643	15.46
High	50-100	26.5356	27.42
Very High	100-200	0.819	0.85
Total		96.7779	100.00

Table 7: Average Soil Loss in Study Area (2016)

LULC	Average Soil Loss (t/ha/yr)
Settlement	1.99
Dense Forest	0.49
Open Scrub	27.37
River Bed	0.17
Fellow Land	19.53
Scrub	2.18
Agriculture	18.88
Open Forest	56.58

The result of the physical and chemical analysis of soil samples was used for soil erodibility value ranges in value from 0.01 to 0.065 in the study area (Fig. 9). The *K* factor indicates with a numerical value from 0-1value Few patches are affected by high soil erodibility shown as red colour that represents closer to 0 value is negligible soil erosion or less prone moreover the value closer to 1 is high erosion or high prone (Fig. 9).

Flow Accumulation

The Flow direction operates that natural drainage direction for every pixel in the Digital Elevation Model (DEM). Output Flow direction map shows, after the Flow accumulation operation counts the total number of pixels that will drain into outlets point (Dissmeyer and Foster, 1980) (Fig. 10).

Drainage Density and Stream Frequency

Drainage density (expressed in terms of km/sq.km) indicates the total length of all streams and rivers in a basin divided by the total area of the drainage area which is more water will infiltrate. Fig. 10 and 11 shows the Stream order and flow accumulation map which is categorized into five stream order. Number of streams in one sq. km drainage density, higher would be runoff. Thus, the drainage density characterizes the runoff in the area or in other words, the quantum of rainwater that could have infiltrated. The drainage density in the area has been calculated after the digitization of the drainage pattern of the entire area, so the highest groundwater recharge probability is when the drainage density is low. Stream frequency is the total number of streams in an area indicating how many orders, how many streams and what patterns exist in a given area. Lower stream frequency recharges more groundwater. Hence medium (5 - 10 number stream), high (10) in a square km grid or area. 20 number of flows in one sq km enrichment) and very high (> 20 numbers of flow in one sq km enrichment) is considered correct. (Fig 11).

Topographic Factor (LS)

Topographic factor is constituting by slope steepness *(S)* and slope length *(L)* which are associated with accelerate rate of soil erosion. Steeper slope relates to increase the erosion whereas length of slope defined as distance of slope with slow creeping of soil towards down slope (Desmet and Govers, 1996). LS factor indicates the influence of LS on erosion process. Topographic factor computed by the flow accumulation and percentage of slope with RS computation. The nastiest erosion phenomena happen under range of slope in percentage between 10 to 25. Topographic factor is computed using by following equation;

$$LS = [(Qa\ M)/22.13]^{y} \times (0.65+0.045 \times S_g + 0.0065 \times S_g^2) \quad (4)$$

Where

LS = Topographical Factor;

Q_a= Flow Accumulation grid

S_g = Grid slope in percentage

M = Grid size (X x Y),

y = dimensionless value of 0.2-0.5

The result observed after computation in the study area about the LS factor is range 0.00917-59.1787 shown on map Fig. 12. The value of the topographic factor escalation as the flow accumulation and slope increases in the study area.

Crop Cover and Management Factor *(CP)*

Crop cover and management factor *(CP)* indicates land utilisations practices i.e., cropping pattern, settlement, Dense Forest, Open Scrub, River Bed, Fellow Land, Dense Scrub, Agricultural land and Open Forest, there are eight classifications in the study area maximum area covered by dense forest and open scrub with 42.72% and 22.38% respectively (Table 3 and Fig. 5). The *CP* factor has computed by the LULC map and prepared map (Fig. 13 & 14). The *CP* factor value varies 0 to 1 denotes near to 0 value represents erosion or soil loss is less and near 1 value shows more erosion.

In the study region has been observed *CP* value in each land use land cover classes viz. Orchards 0.05 & 0.5, Forest 0.006 & 0.5, Scrub 0.05& 0.5 and Agriculture 0.5& 0.8 respectively *C&P* value indicated separately. Fallow land, Settlement and River bed have no value (Table 5). Only one agriculture class observed *P* factor comprise value 0.8, it is closer to 1 i.e., soil erosion occurs is moderate near to high. Moreover, CP value in remaining the LULC classes under value 0.5 accepting agricultural land which indicates less erosion or a negligible amount of soil loss.

Soil Erosion Risk

After deriving all parameters of the RUSLE soil erosion risk map have generated. The extent of soil erosion risk class in Tons watershed can be seen in the soil risk map and the extent of soil risk class wise percentage shown in the table (JE Gilley et al., 1977). The formula to generate the soil erosion risk is given here as A=R × K × L × S × C × P. In the watershed 0.85 % under very high erosion, 27.42 % under high erosion, 15.46 % under moderate-high erosion, 4.87 % under moderate erosion and 51.47 % under slight erosion class. Soil erosion risk assessment has been categorised in five indexes as Slight 1-10, moderate 10-25, moderate-high 25-50, high 50-100 and very high 100-200 especially propounded for the study area. In the study area, soil erosion risk assessed by t/h/y under five index values observed as 49.7439 h under slight, 4.7151h under moderate, 14.9643 h under moderate-high and 26.5356 h area under the high and 0.819 h area under soil erosion risk-prone (Table 5 & Fig. 15). After the computation RKLSCP as RUSLE in remote sensing and GIS platform, results found average soil loss in each class of LULC in ton/ha/yr as Settlement 1.99, Dense Forest 0.49, Open Scrub 27.37, River Bed 0.17, Fellow Land 19.53, Scrub 2.18, Agriculture 18.88 and Open Forest 56.58 (Table 7, Fig. 15 & 16).

The study area was undertaken in a part of Dehradun district Uttarakhand with aim to assess the soil erosion risk in the Tons watershed using Remote sensing and GIS techniques. Assessment of soil erosion has been done with the help of Remote Sensing and GIS using RUSLE model. GIS incorporation with Remote Sensing is a peaceful technique for modeling soil erosion because major input parameters to the model can be derived from Remote Sensing data and the modelling part can be easily done in the GIS environment. The finding of the study; Average annual soil loss of the Tons watershed is 63 ton/ha/year. It is clear from the analysis of soil erosion in Tons watershed that the major cause of soil erosion is slope, heavy rainfall and deforestation to some extent. Highest soil loss from scrubland, current fallow, barren land, and low intensity of cultivation. Lowest soil loss from the dense forest. Most of the area is dominated by dense forest. For barren land has suggested restoration of vegetation cover especially by tree planting. The RUSLE model allowed describing the process of erosion and hence, the conservation method can be done within separate phases of erosion process. As a result of the study, the following conservation measures are suggested for scrubland, agriculture, and barren land in high and very high priority classes. The study permitted and recommended to the conservation of soil loss and soil erosion in the Himalayan regions.

RS and GIS help users to identify the soil erosion affected areas in Tons watershed. The observation and findings will help to conservation of soil loss and management of severe patches in Tons watershed. The outcomes will assist in the preparation of hazard zonation and disaster natural disaster management planning for a better manner. Tons watershed under the hilly region, because it often occurs natural events viz., cloud burst, flash flood, heavy rainfall, landslide, etc. therefore this paper will helpful for better management in Tons watershed. Remote Sensing and GIS is the most efficient tool to calculate and computation such as massive and complicated data rather than using empirical methods. Advanced techniques refer to getting reliable results and outcomes along with must be recommended validation with primary data and ground-truthing simultaneously.

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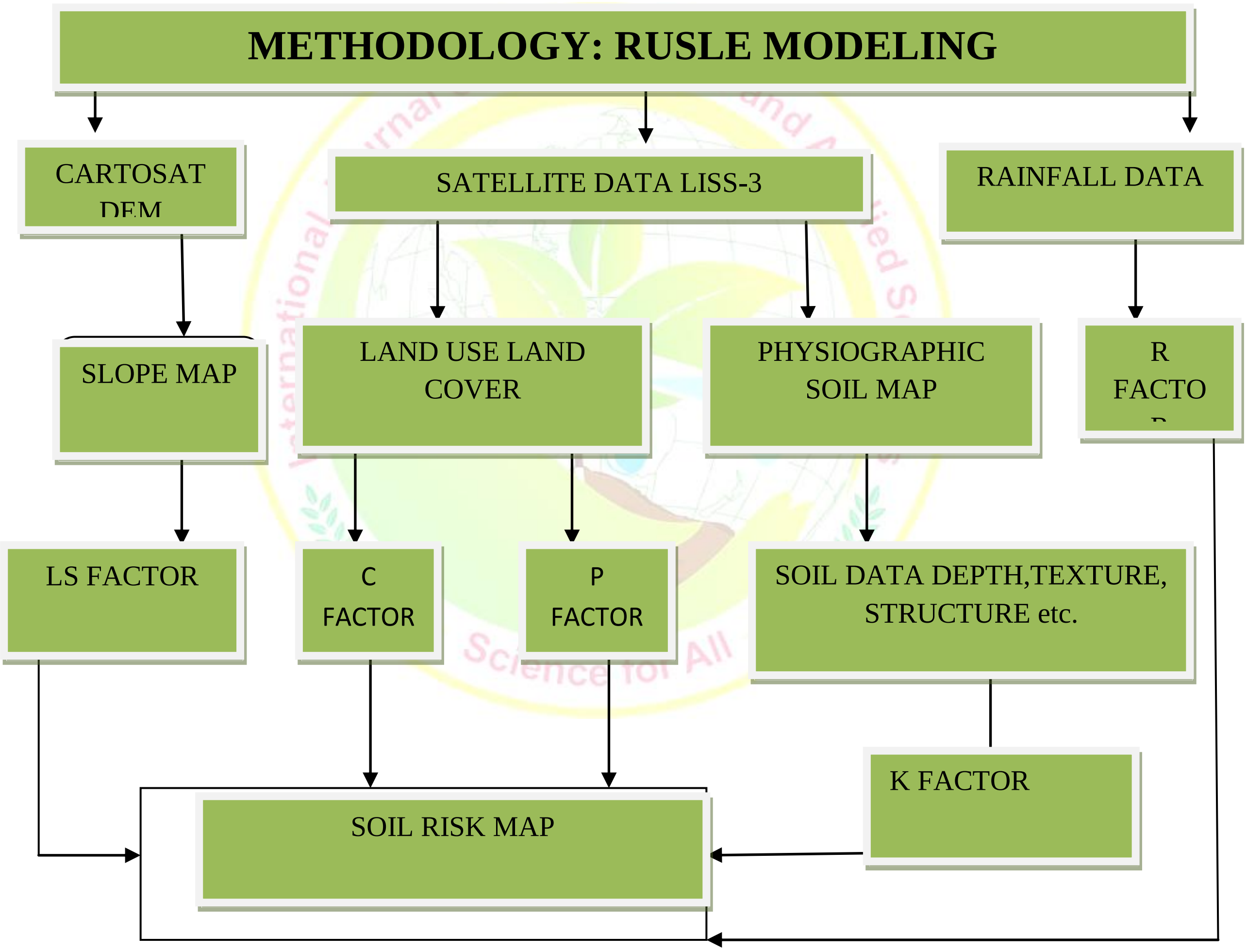


Fig. 1: Methodology

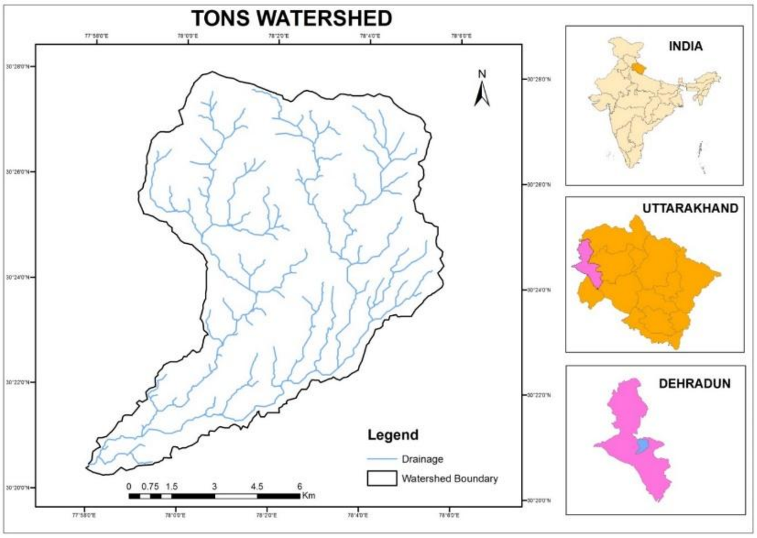


Fig. 2: Study Area, Tons Watershed

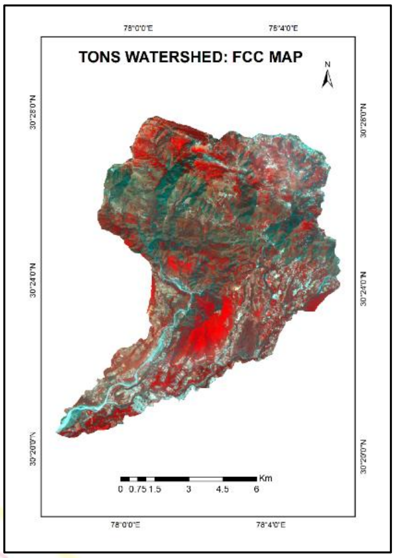


Fig. 3: FCC Map of the Study Area

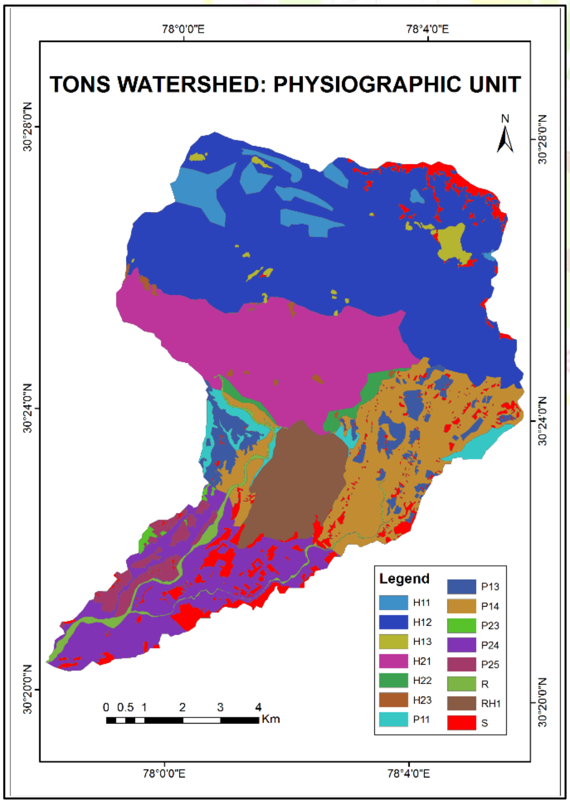


Fig. 4: Physiographic Units

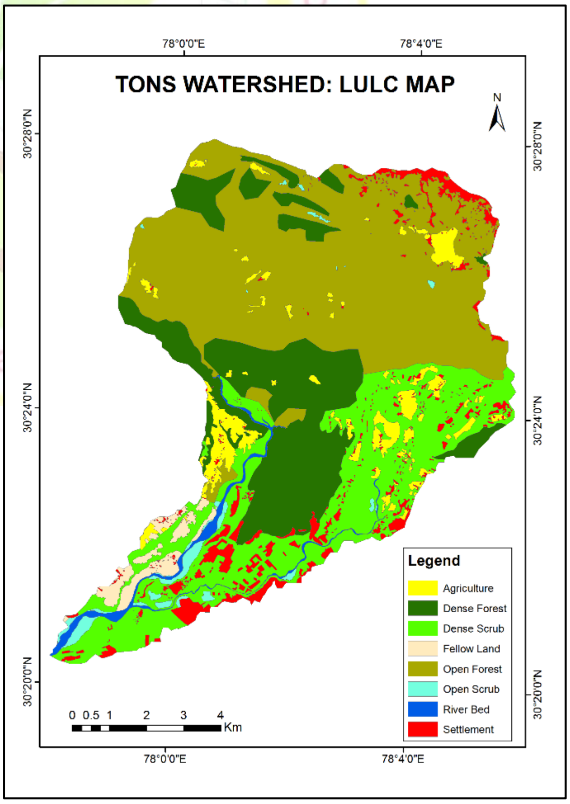


Fig.5: LULC

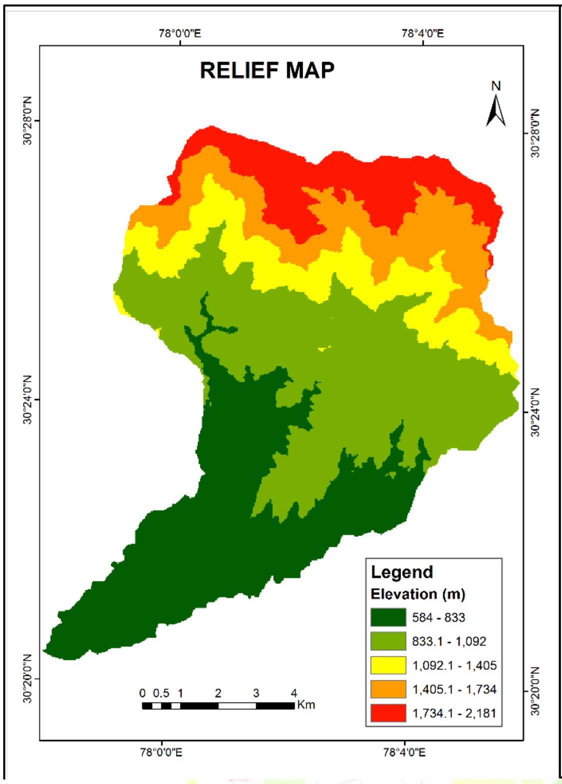


Fig. 6: Relief

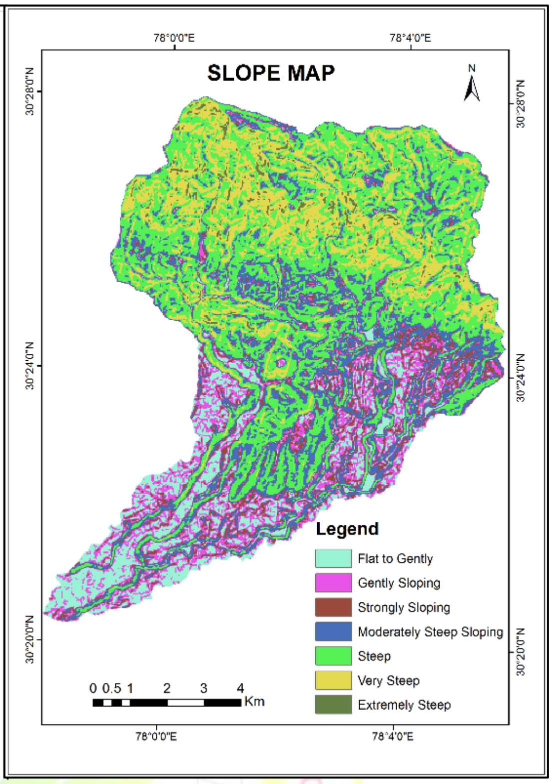


Fig. 7: Slope

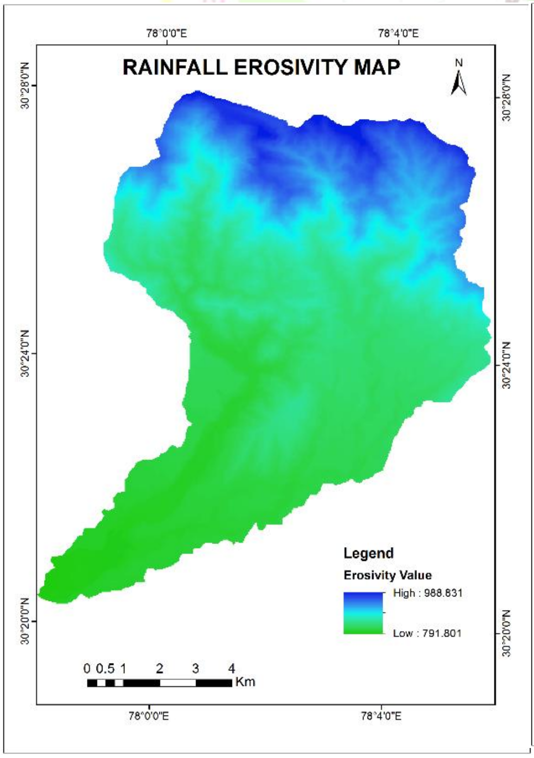


Fig. 8: Rainfall Erosivity (R)

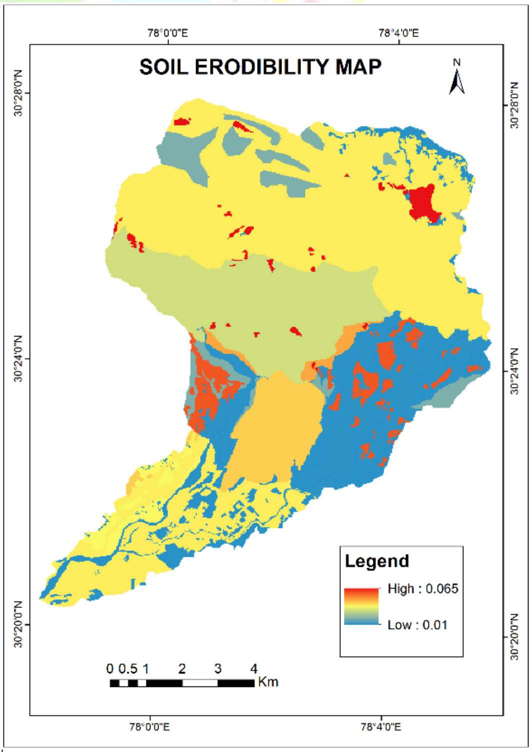
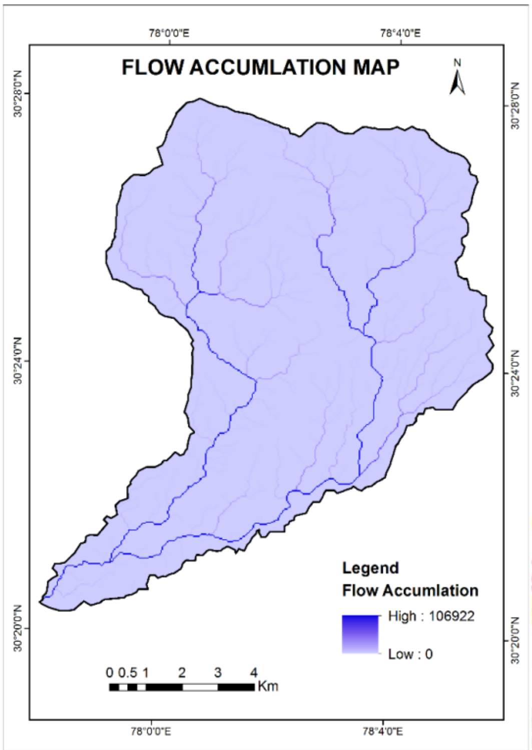


Fig. 9 Soil Erodibility (K)



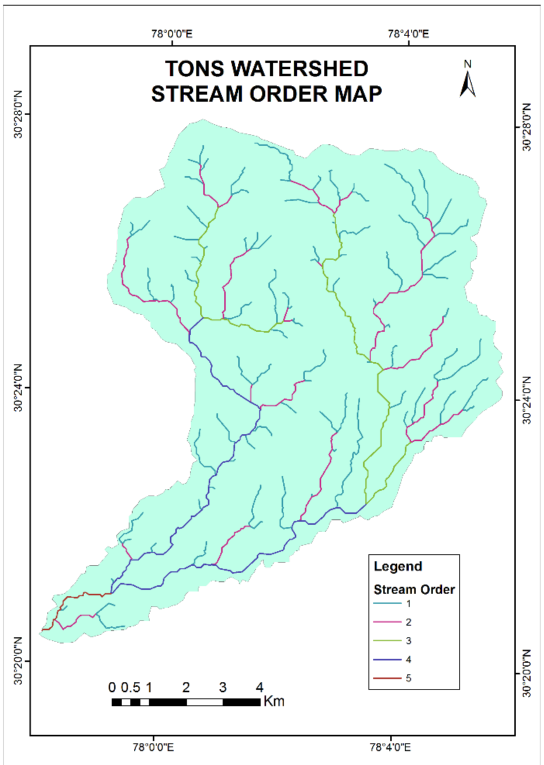
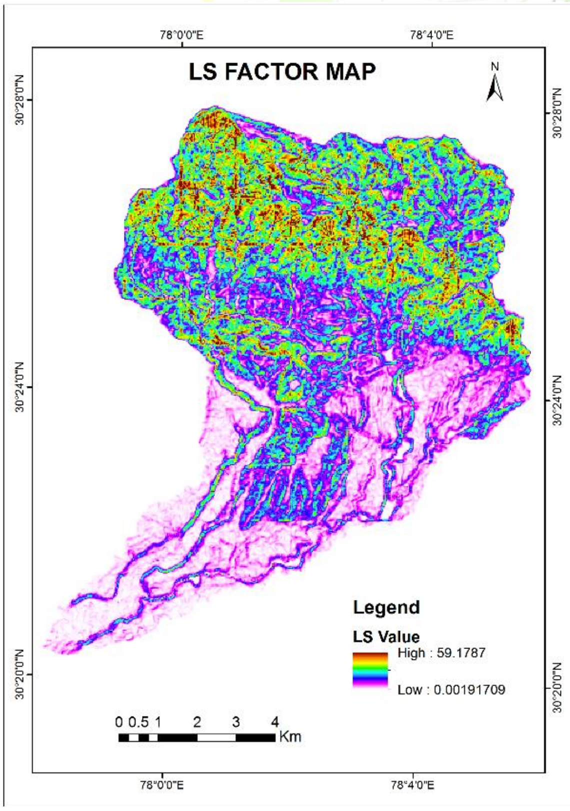


Fig. 10: Flow Accumulation **Fig. 11. Stream Order**



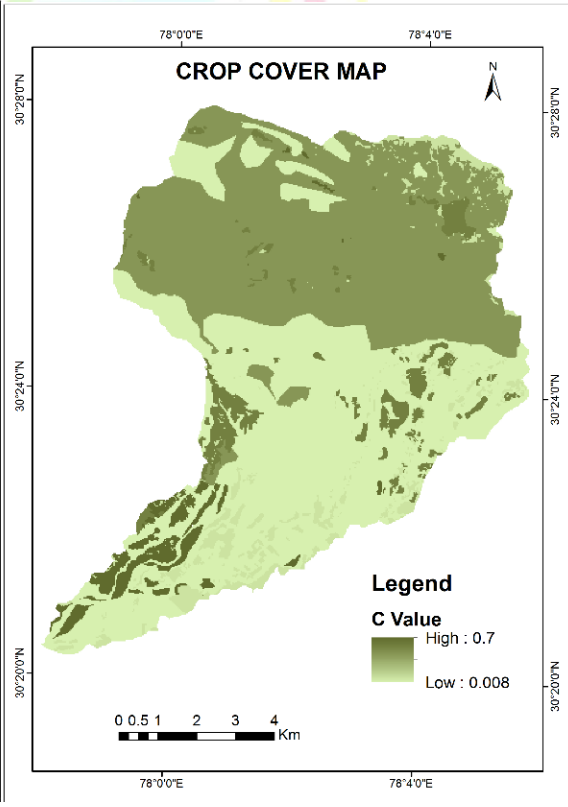
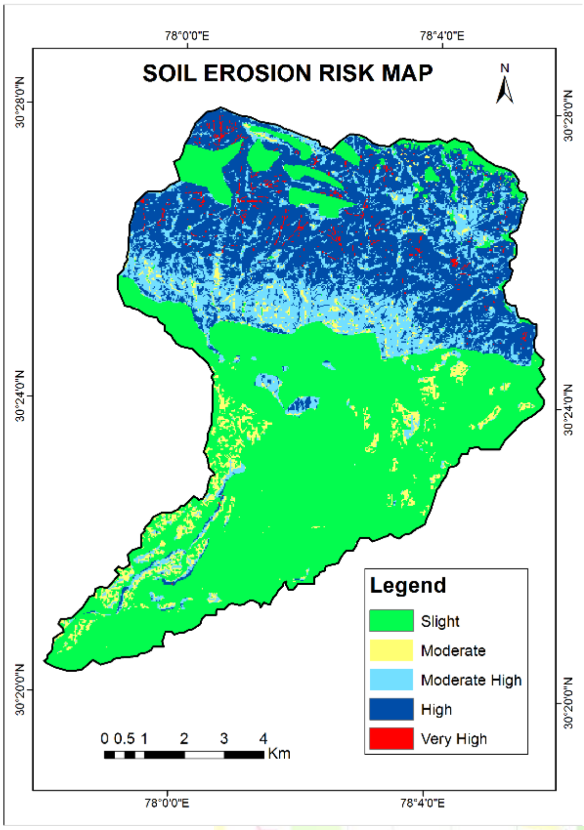


Fig. 12: Topographic (LS) **Factor Fig. 13: C Factor**



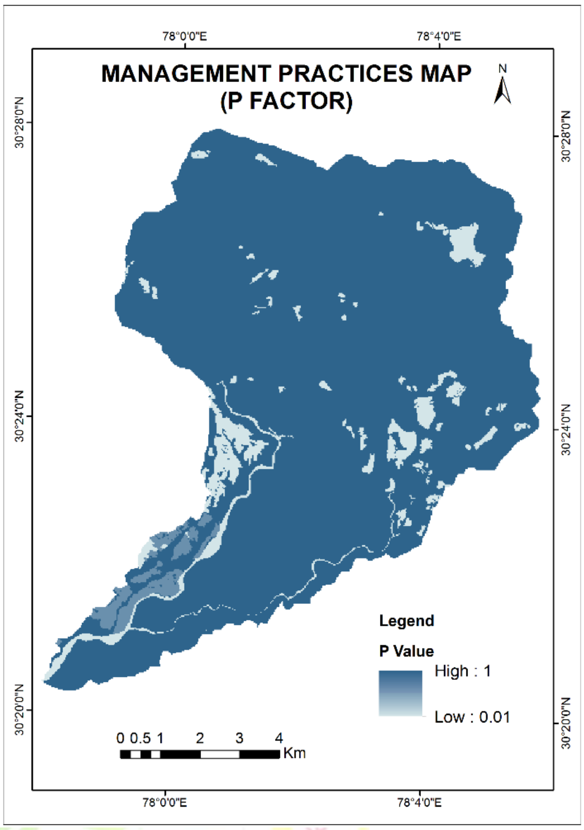


Fig. 14: P Factor **Fig. 15: Soil Erosion Risk**

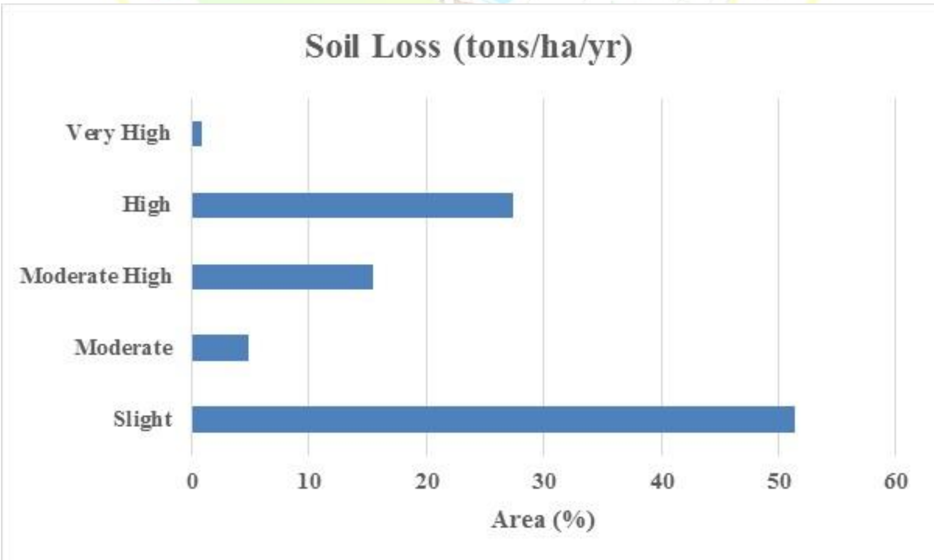


Fig. 17

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Research Article

Actual and Potential Land Productivity of Some Soils of Sohag-Red Sea Road Sides, Eastern Desert, Egypt

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ABSTRACT
Egyptian Government focuses on development projects especially in new lands such as Sohag-Red Sea road to improve tourism and agricultural activities. This study aims to assess the actual and potential land productivity. Seventeen soil profiles were chosen depending on the six mapping units of the study area. Soil profiles were drilled and soil samples were collected from each horizon. Nine land characteristics were measured/estimated *viz*. soil moisture content (H), drainage (D), depth (P), texture (T), soluble salts content (S), average nutrient content (N), organic matter content (O), cationic exchange capacity (A) and reserves weatherable minerals (M). Soil samples were analyzed for their mentioned parameters using the standard methods of soil analysis. Accordingly, land productivity (PI) and potentiality (P`I) indices were calculated for all studied soil profiles. The results revealed that actual land productivity of the studied area is extremely poor and can be enhanced 17 times by improving soil moisture content, texture, and organic matter content as the most important controlling-factors. Actual and potential land productivity maps were generated using Arc GIS 10.1 software. These results may help decision-makers for new lands reclamation planning and better agricultural production.
Keywords: *Land productivity, soil mapping, Sohag-Red Sea Road.*

INTRODUCTION

With the rapid population growth and urban sprawl, the soils of the Nile River valley and delta start to lose their fertility and productivity (Mustafa and Negim 2016). Therefore, the Egyptian Government focused on horizontal expansion for reclaiming new lands for increasing agricultural production and reducing the pressure on the existing agricultural land (FAO 2006). Moreover, the golden triangle project which covers a very wide area in the Eastern Desert is one of the most important reclamation programs (NGage 2016). For that, the role of soil researchers appears to provide the necessary information and data to initiate the reclamation of such lands and for developing proper soil management practices and land-use planning (Denton *et al.* 2017). The low-fertility desert lands represent most of Egypt's area, distributed in the east and west Nile Valley. The soils of the Eastern desert are neutral to alkaline, calcareous with a coarse texture and ranging from non-saline to strong-saline soils. Organic carbon content is low (Ibrahim and Ali 2009). The potentiality of GIS for assessing land productivity is important for better land resource management and enhancing land productivity (Ibrahim et al., 2017). This study aims to evaluate the current land productivity status of some soils of Sohag-Red Sea road-sides and also estimate the potential land productivity after the improvement of land productivity parameters.

MATERIALS AND METHODS

Site description

The study site is a part of the Sohag-Red Sea road in the area of Wadi Qena in the Eastern Desert. This area lies between the 26°.65, 26°.75 latitudes (N) and 32°.7, 32°.9 longitudes (E) with an area of ≈204 km^2. The area under investigation is located between the Nile Valley in the West and the Red Sea mountains in the East. The location map of the studied area and soil profiles' locations is shown in figure (1). Wadi Qena is covered with Quaternary deposits which are consisting of gravels, sands, and cemented by fine clay materials (El-Shamy 1988). Wadi Qena catchment is a typical arid basin, which is characterized by an extremely arid climate. The geological map is shown in figure (2). The annual rainfall ranges between 2.75 and 50 mm, while heavy showers are recorded occasionally during winter causing flash floods. The minimum temperature is ranging between 5ºC and 14ºC and the maximum temperature is ranging between 28ºC and 42ºC. The relative humidity (RH) ranges between 30% and 56%. The maximum monthly evapotranspiration is 23.5 mm during June, while the minimum value is 3.1 mm during December (Awad 2008). Prevailing winds are dominantly from the northwest to the southeast with an

average maximum speed of 10 knots/h. The natural vegetation is sparse and distributed randomly over the area. Moringa, Wild Caper, and Salvadoroprisca are the common natural vegetation in the area. Furthermore, agricultural activities are very limited in the area (El-Zawahry *et al.* 2004). The area under investigation is represented by six mapping units i.e., Wadi-Floor (WF), Low-elevated Sand Sheet (LSS), High-elevated Sand Sheet (HSS), Bajada (B), Piedmont (P), and Table Land (TL).

Field-work

Seventeen soil profiles were selected according to the grid system for sampling, and mapping units of the studied area. Latitudes and longitudes for each soil profile were defined by using GPS "Garmin–eTrix" under the WGS84 coordinate system. A detailed morphological description for all soil profiles was noted based on FAO (2006).

Soil analysis

Soil moisture content, drainage, and soil depth were estimated using the in situ descriptions of soil profiles. Soil samples were air-dried, grounded, and 2mm sieved. Particle size distribution was determined by the international pipette method (Jackson 1969). Electrical conductivity (EC) was determined in 1:1 soil-water extract using EC-meter (Jackson 1973). Organic matter contents were determined using the wet-oxidation method (Walkley and Black, 1934). Cation Exchange Capacity (CEC) was determined by sodium acetate (pH≈8.5) and exchangeable cations by ammonium acetate (pH≈7.0) methods (Black 1982). Exchangeable Ca^{+2} and Mg^{+2} were determined using the EDTA titration method, Na^{+1} and K^{+1} were determined using a flame photometer. The base saturation percentage was calculated as a ratio of the measured basic exchangeable cations and CEC.

Estimation of actual and potential land productivity

The actual and potential productivity indices were computed by adopting the procedure of (Riquier *et al.,* 1970). In this method, nine factors were considered for determining soil productivity, soil moisture content (H), drainage (D), depth (P), texture (T), soluble salts content (S), average nutrient content (N), organic matter content (O), soil cationic exchange capacity (A) and reserves of weatherable minerals (M). Each factor was rated on a scale from 0 to 100 and the actual percentages were multiplied by each other to calculate the productivity index (PI) as expressed in (Equation.1).

$$PI = H\times D\times P\times T\times S\times A\times N\times M\times O. \qquad (1)$$

The resultant index for productivity, also lying between 0 and 100, was set against a scale placing the soil in one or other of five productivity classes, namely excellent, good, average, poor, and extremely poor.

The potentiality index (P`I) was calculated as expressed by (Equation.2) after improving characterizations which considered as limitations of productivity. Then the coefficient of improvement of land productivity (P`I /PI) was estimated (Equation.3).

$$P`I = H\times D\times P\times T\times S\times A\times N\times M\times O+10\%. \qquad (2)$$

P`I /PI = Potentiality Index / Productivity Index. (3)

Mapping of land productivity

Actual and potential land productivity maps were generated using the IDW-interpolation tool in Arc GIS 10.1 software (ESRI, 2012).

RESULTS AND DISCUSSION

Soil profiles' characterization

The geo-coordinates of soil profiles' locations as well as elevation values were collected using GPS and recorded in decimal degree format. These values were used for mapping with the utility of corresponding soil attributes' data of each soil profile. Soil morphological parameters such as soil moisture content, soil drainage, and soil profile's depth were described and estimated in situ. Table (1) shows the characterization of soil profiles for all land productivity parameters. From the obtained data, it was observed that all mapping units and their representative soil profiles having a soil moisture content in the rooting zone below wilting point around 9 months of the year. These soils are well-drained and deep (more than 120 cm depth). The soils of the area under investigation are coarse-textured which sand content is high. Soil texture of WF and B units are sandy loam while the sand texture is dominant in other mapping units. The total soluble salts in these soils were ranged from low to moderate (0.36% to 0.56%) with an average of 0.49%, while soil organic matter content was low and ranged from 0.14% to 0.40% with an average of 0.24%. The cationic exchange capacity of these soils were ranged from 1.92 to 6.10 cmole(p^+).kg^{-1} with an average of 3.50 cmole(p^+).kg^{-1}. The minimum and maximum values of base saturation were 79.60% and 95.80%, respectively with a mean value of 86.77%.

Actual land productivity evaluation

Soil moisture content could be categorized as H2c and take a value of 40, which moisture is below wilting point around 9 months of the year. Soil depth, soil drainage, and average nutrient content were categorized as P6, D4, and N5, respectively then each of them was given a value of 100. Soil texture has T2b class and rated with a value of 10 whereas; coarse-textured soil (more than 45 percent sand) is there. Regarding soil soluble salts, all soil profiles are under the S3 category (50), except one profile in the HSS unit, and other in the TL unit where having S2 class (70). The content of organic matter in these soils is low (O1) whereas; less than 1% and rated with a value of 85. The soils of the studied area have cationic exchange capacity less than 5 meq/100g soil (A0) for all soil profiles except profiles number (1, 3, 10, and 13) which have CEC more than 5 and less than 20 meq/100g soil (A1). The A0 and A1 classes were rated with values of 85 and 90, respectively

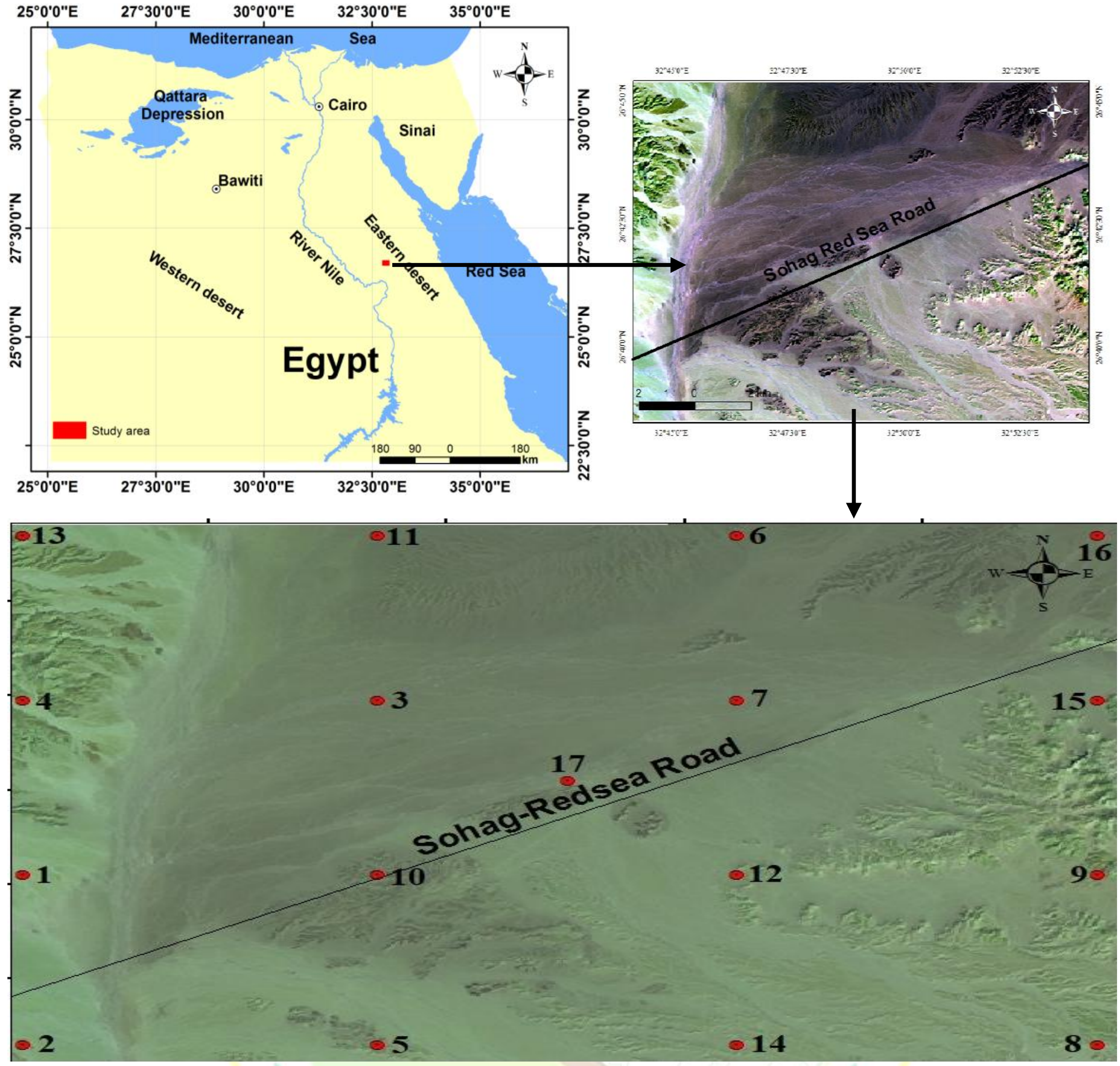


Fig.1: Location map of the studied area and soil profiles' locations.

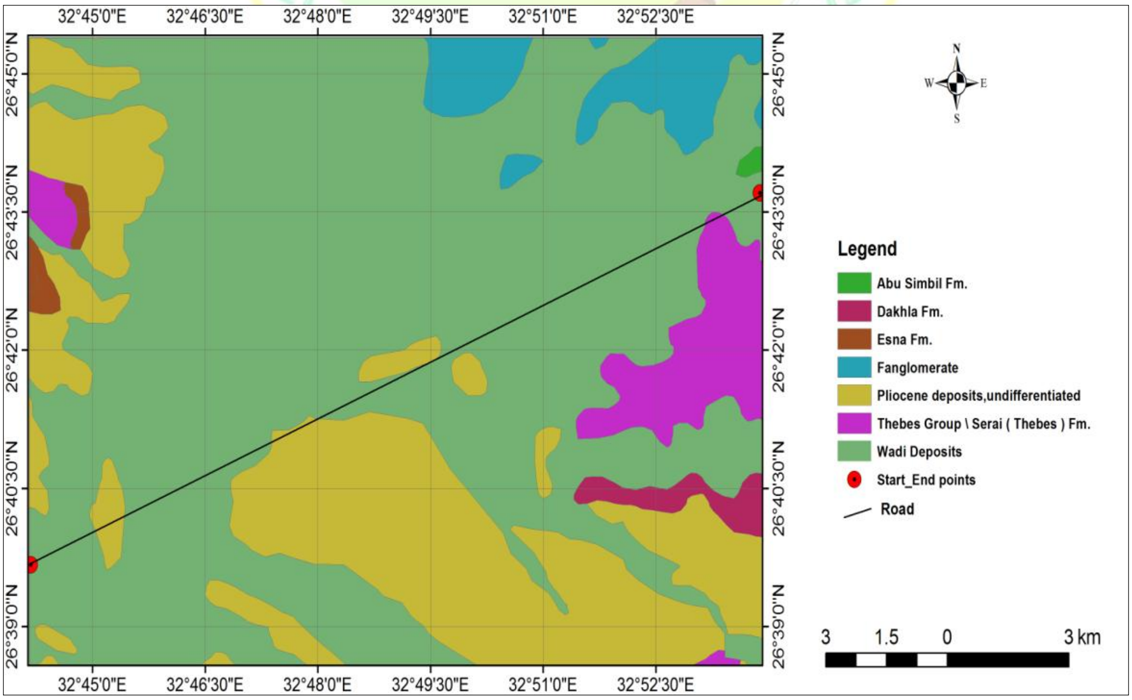


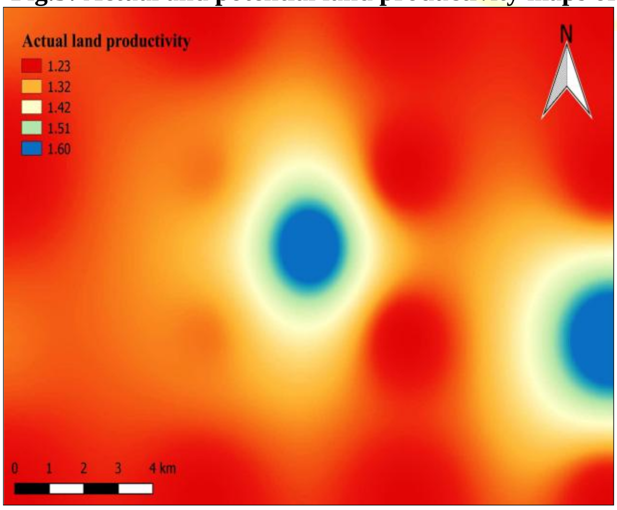
Fig.2: Geological map of the study area.

Table 1: Characterization of soil profiles of the studied area.

Profile No.	Mapping unit	Longitude	Latitude	H	D	P	T	S	O	M	A	N
1	Wadi Floor (WF)	32.738	26.682	<5	Well	130+	LS	0.44	0.34	Very Low	6.10	84.80
2		32.738	26.646	<5	Well	120+	S	0.56	0.29	Very Low	4.30	92.90
3		32.790	26.719	<5	Well	120+	LS	0.46	0.31	Very Low	5.29	85.42
4	Low-elevated Sand Sheet (LSS)	32.738	26.719	<5	Well	130+	S	0.55	0.20	Very Low	2.88	80.66
5		32.790	26.646	<5	Well	130+	S	0.45	0.30	Very Low	2.13	87.53
6		32.843	26.754	<5	Well	125+	LS	0.48	0.27	Very Low	2.44	82.54
7		32.843	26.719	<5	Well	120+	S	0.52	0.33	Very Low	2.51	84.36
8	High-elevated sand Sheet (HSS)	32.896	26.646	<5	Well	120+	S	0.52	0.14	Very Low	2.30	91.33
9		32.896	26.682	<5	Well	120+	S	0.39	0.18	Very Low	1.92	89.80
10	Bajada (B)	32.790	26.682	<5	Well	110+	LS	0.53	0.29	Very Low	5.48	95.80
11		32.790	26.754	<5	Well	120+	LS	0.57	0.19	Very Low	3.23	88.95
12		32.843	26.682	<5	Well	125+	LS	0.53	0.22	Very Low	4.24	86.91
13	Piedmont (P)	32.738	26.754	<5	Well	130+	LS	0.51	0.40	Very Low	5.38	79.60
14		32.843	26.646	<5	Well	130+	S	0.49	0.14	Very Low	2.88	88.23
15		32.896	26.719	<5	Well	120+	LS	0.49	0.20	Very Low	3.28	87.87
16	Table Land (TL)	32.896	26.754	<5	Well	130+	S	0.52	0.16	Very Low	2.58	87.50
17		32.818	26.702	<5	Well	130+	S	0.36	0.16	Very Low	2.48	80.90

H: Moisture Content (%), D: Soil Drainage, P: Soil Depth (cm), T: Soil Texture Grade, S: Total soluble salts (%), O: Soil organic matter (%), M: Reserves of weatherable minerals, A: Cationic exchange capacity, and N: Average nutrient content/Base saturation.

Fig.3: Actual and potential land productivity maps of the studied area.



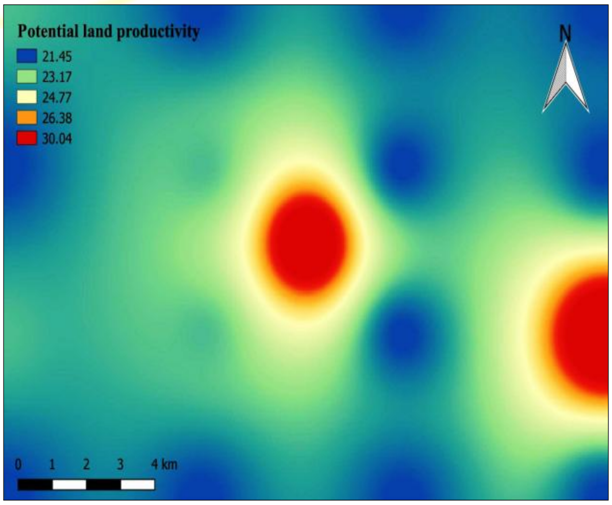


Table 2: Actual land productivity parameters.

Profile No.	Mapping unit	H	D	P	T	S	O	M	A	N	PI
1	Wadi Floor (WF)	H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A1 (90)	N5 (100)	PI5 (1.30)
2		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	P5 (1.23)
3		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A1 (90)	N5 (100)	PI5 (1.30)
4	Low-elevated Sand Sheet (LSS)	H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
5		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
6		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
7		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
8	High-elevated sand Sheet (HSS)	H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
9		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S2 (70)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.72)
10	Bajada (B)	H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A1 (90)	N5 (100)	PI5 (1.30)
11		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
12		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
13	Piedmont (P)	H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A1 (90)	N5 (100)	PI5 (1.30)
14		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
15		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
16	Table Land (TL)	H2c (40)	D4 (100)	P6 (100)	T2b (10)	S3 (50)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.23)
17		H2c (40)	D4 (100)	P6 (100)	T2b (10)	S2 (70)	O1 (85)	M1 (85)	A0 (85)	N5 (100)	PI5 (1.72)

H2c: Soil moisture (H) in rooting zone below wilting point around 9 months of the year, D4: Well-drained soil with a deep water table (hydromorphic horizon at over 120 cm depth) and no water-logging of the soil profile, P6: Very deep soil with over 120 cm depth, T2b: Soil texture and structure of root zone which extremely coarse-textured soil (more than 45 percent sand), S2: Total soluble salts between 0.2 to 0.4 percent, S3: Total soluble salts between 0.4 to 0.6 percent, O1: Soil organic matter in A1 horizon which less than one percent, M1: Reserves of weatherable minerals in B horizon very low to Nil, A0: Cationic exchange capacity in B horizon less than 5 meq/100g, A1: Cationic exchange capacity in B horizon less than 20 meq/100g, N5: Average nutrient content in A horizon whereas base saturation over 75 percent, and PI5: Land productivity is extremely poor to Nil.

Table 3: Potential land productivity parameters after improvement.

Profile No.	Mapping unit	H	D	P	T	S	O	M	A	N	P`I
1	Wadi Floor (WF)	H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A1 (90)	N5 (100)	P`I3 (22.72)
2		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
3		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A1 (90)	N5 (100)	P`I3 (22.72)
4	Low-elevated Sand Sheet (LSS)	H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
5		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
6		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
7		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
8	High-elevated sand Sheet (HSS)	H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
9		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S2 (70)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (30.04)
10	Bajada (B)	H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A1 (90)	N5 (100)	P`I3 (22.72)
11		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
12		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
13	Piedmont (P)	H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A1 (90)	N5 (100)	P`I3 (22.72)
14		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
15		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
16	Table Land (TL)	H4c (90)	D4 (100)	P6 (100)	T6a (60)	S3 (50)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (21.46)
17		H4c (90)	D4 (100)	P6 (100)	T6a (60)	S2 (70)	O3 (100)	M1 (85)	A0 (85)	N5 (100)	P`I3 (30.04)

H4c: Soil moisture content (H) when rooting zone below wilting point for 3 months and wet below field capacity for over 6 months of the year, T6a: texture and structure of root zone when dominant texture grades are heavy sandy loam, sandy clay, clay loam, silty clay loam, or silt, O3: Soil organic matter in A1 horizon is averaged from 2 to 5 percent, and P`I3: Land potential productivity after improvement which under average productivity class.

The productivity index was calculated for each soil profile and it is obvious that all soil profiles have extreme poor to nil land productivity (PI between 0 and 7). All related data are shown in table (2).

Improvement of land productivity parameters

From the previous results, the limitations of these soils for land productivity are soil moisture content (H), Soil texture (T), and soil organic matter (O). These parameters can be enhanced to increase land productivity. Therefore, these soils shall be irrigated using the supplementary methods of irrigation such as sprinkler irrigation. This process will increase the rate of soil moisture parameter from H2c to H4c which is given 90 as the rating. The surface layer (0-25 cm) of these soils can be mixed with heavy textured soil which transported from other agricultural lands. The addition of organic materials and nutrients application of manure, crop rotation also improvement of humic conditions will improve soil texture. These practices may enhance texture from T2b to T6a (from 10 to 60). After the improvement of organic matter, it can be increased from O1 to O3 (85 to 100). By improvement of organic matter, 10% will add to the final Index. The data of land productivity parameters after improvement are shown in table (3).

Potential land productivity evaluation

The data of land productivity parameters after improvement were used to calculate land potential productivity (P`I) which ranged from 21.46 to 30.04. These soils were found to be average in potential productivity. The coefficient of improvement of the studied area (P`I/PI) was calculated and its value was 17.48. It means that productivity can be multiplied by more than 17 times with the application of all suitable management techniques.

Mapping of actual and potential land productivity

The IDW-Interpolation tool in Arc GIS 10.1 software was used for generating actual and potential land productivity maps as shown in figure (3). These maps show that the Central and Eastern parts of the studied area have better productivity compared to rest areas. Land productivity increased after the improvement of land productivity parameters.

The soils of the studied area have low moisture content. These soils are well-drained, deep, and coarse-textured. Soil organic matter content is low while total soluble salts are ranged from low to moderate. Moreover, CEC is low and BS is more than 75%. The actual land productivity index showed that these soils are extremely poor in productivity. Some practices and land management processes should be followed to improve land productivity. The limitations in these soils are soil moisture content, soil texture, and soil organic matter. The potential land productivity can be increased 17 times after improvement. The integration of soil surveying, sampling, laboratory analysis, and GIS technique found to be an effective tool for producing spatial information as well as land productivity data. These data can be utilized for better land use management, planning for new lands reclamation, and enhancing agricultural productivity.

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Research Article

Effects of Water Intervals on Growth and Yield of Three Chickpea Cultivars (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was conducted during the winter season, 2017-2018, at Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Khartoum State, Sudan. The objective of this experiment was to assess the effect of water intervals on growth and yield of three Chickpea cultivars, namely Atmore, Wad-Hamid and Shendi. Split-plot design was adopted with three replications. The three water intervals treatments were (10, 20 and 30) days which arranged in the main plots and three chickpea cultivars placed in subplot. Plant parameters measured were plant height (cm), number of leaves per plant, number of branches per plant, number of pods per plant, weight of pods per plant (g), number of seeds per pod, weight of seeds per plant (g) and hundred seed weight (g). The results showed that there were significant differences among the treatments in number of leaves, number of branches, number of seeds per pod and hundred seeds weight. However, there were highly significant differences in plant height, number of pods per plant, weight of pods per plant and weight of seeds per plant. Irrigation every ten days gave best results in most of the studied parameters, irrespective to cultivars. The result revealed that no significant differences occur between chickpea cultivars in all parameters measured except in the number of seeds per pod and hundred seeds weight.
Key words: *water, interval, Chickpea, growth and yield.*

INTRODUCTION

Chickpea *(Cicer arietinum* L.) is one of the most important grain legumes crops in the world, belongs to the family Fabaceae and sub family Faboideae (Knights *et. al.*, 2007). The genus *Cicer* consists of 9 annual and 31 perennial species, *arietinum* is the only cultivated annual species (Muchlabuer, 1993). Chickpea is the third important pulse crop, and 15% of the world total pulse productions belong to this crop (FAO, 2010). It is grown in more than 50 countries, 89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% Americas and 0.4% in Europe (Guar, *et al.*, 2010).Today, scientists are using several approaches trying to understand and assess the mechanisms through which the plant overcomes drought stress (Farshadfar, *et. al.*, 2013). In Sudan, chickpea is grown mainly in the north part of the country where environmental conditions suit their production better than in other parts of the country. Their growing season is restricted to a short period of time by the high temperatures prevailing at the beginning and end of winter (Mohamed, 1998). The total cultivated area was estimated at about 6851 ha with average seed yield of 17349 kg/ha (FAO, 2017). The area production and yield of chickpea have all shown an increasing trend as the crop spreads to new areas and is grown in different parts of the country under residual moisture and irrigation systems (Abdellatif and Abdalwahab, 2017). Increasing plant density affected most of growth attributes and resulted in substantial increase in seeds yield per unit area, while seeds yield per plant was negatively affected by increasing plant density, (Naim, 2001). Chickpea is sensitive to water stress, particularly during the reproductive stage and its yield depends upon the water supply from flowering to pod filling stage (Naim, 2001). In order to counter this drought stress, development of early maturing cultivars will make judicious use of the available soil moisture efficiently and produce relatively higher yields. Critical review made by (Upadhyaya, *et. al.*, (2012) illustrates efficient methods for phenotyping with respect to drought in chickpea and pigeon pea. Therefore the objective of this experiment was designed to study the effect of irrigation intervals on growth and yield of three chickpea cultivars.

MATERIALS AND METHODS

The Experiment was carried out in the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, Khartoum North, during the winter season of 2017 – 2018. The area lay in a tropical, semi-arid region. It is located within the grids latitudes 15o - 40o N, 32 o

32" E and altitude 386 m above sea level, where the rainfall lasts for three months (July to September). The soil of the study area is clay described as montmorillonite with pH ranges between 7.8 - 8.5 (Abdelhafiz, 2001).

The studied factors treatments were arranged in split-plot design in three replications. The two study factors used in this experiment includes water intervals and chickpea cultivars. The three water intervals treatments used in the study were (10, 20 and 30) days irrigation interval which arranged in the main plots and three chickpea cultivars placed in subplot namely Atmore, Shendi, and Wad-Hamid which obtained from Hudeiba Research Station, Agricultural Research Corporation (ARC), Sudan.

The land was ploughed, harrowed, leveled and the ridge was formed. The area of the experiment was divided into plot; the plot size was 7 m^2 (3.5 × 2). Each plot consists of four ridges 70 cm apart and 1.5 m long. Three seeds per hole from each cultivar were sown manually in the middle of the ridge in late December 2017. The spacing between holes was 15 cm. After sowing land was immediately irrigated and subsequent irrigation was made every two week till 30 days, thereafter, the irrigation intervals treatments were applied as following 10, 20 and 30 days irrigation interval, chickpea seedlings were thinned to two plants per hole. Hand weeding was practiced two times at 30 and 50 days after sowing.

Five plants were randomly selected and tagged from the middle rows of each plot, to measure plant height (cm), number of leaves /plant and number of branches / plant at 60 and 90 days after sowing. Number of pods /plant, weight of pods /plant (g), number of seeds/ pod, weight of seeds (g), and weight of 100 seeds (g) was done after the crop was harvested.

Data collected in this study were statistically analysis according to analysis of variance (ANOVA), and means were separated for significant by Least Significant Differences Test (LSD) at 5 % level using statistic 8 computer program.

RESULTS AND DISCUSSION

The results revealed that there were no significant differences in plant height between chickpea cultivars, while there was a highly significant difference in water intervals. Chickpea cultivar irrigated every 10 days, displayed the highest plant height (34.1 cm), while, irrigation after 20 and 30 days decreased plant height significantly to 26.0 cm and 23.6 cm, respectively (fig.1). Plant height was significantly affected by water intervals; similar result was found by (Ahmed, 2006). The highest plant height was found in Atmore at 10 days interval, while the lowest was found in Shendi cultivar at 30 days intervals. It possible that cultivar Atmore is more tolerance to the stress condition which may have lead to its superiority our result was agreed with Mohamed *et. al.* (2015).

In general, chickpea cultivars irrigated after 10 days display highest number of leaves. However, irrigation after 30 days sustained the lowest number. Atmore cultivar displayed the highest leaves, followed by descending order by Wad-Hamid and Shendi. (Fig. 2). No significant differences in number of leaves between chickpea cultivars, the highest number of leaves were found in Atmore cultivar at 10 days irrigation while the lowest number of leaves was found in Shendi cultivar at 30 days irrigation, this may indicated that Atmore cultivar has more stress tolerance characteristic than Shendi and Wad Hamid. Water intervals had significantly effect on leaves number. Among all water intervals, Atmore cultivar irrigated after 10 days displayed the highest number of leaves followed by Wad Hamid and Shendi. And this perhaps referred to the role of water stress in old leaves, which will lead to shedding and resulting to reduce the total number of leaves. (AllaJabow, *et. al.*, 2015) they found that the effect of water stress coincides with various growth stage such as germination; seedling and shoot length.

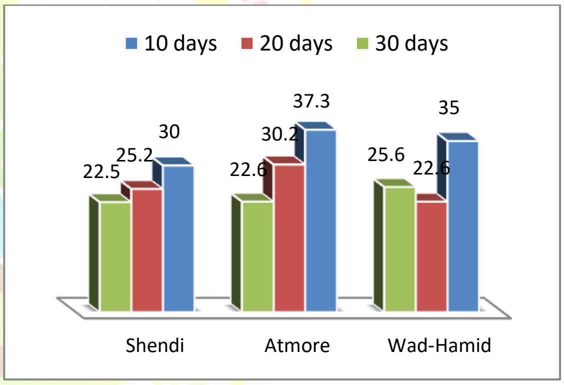

Fig.1. Effect of water interval on plant height (cm) of chickpea cultivars

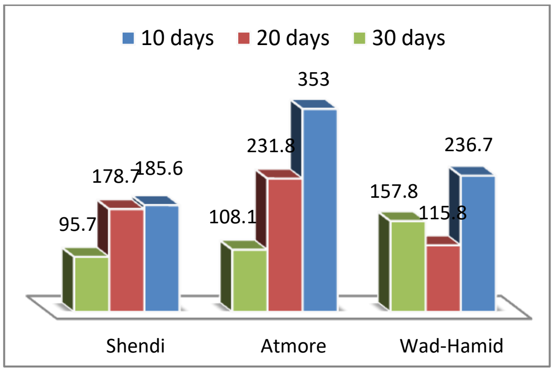

Fig.2. Effect of water interval on number of leaves/ plant of chickpea cultivars

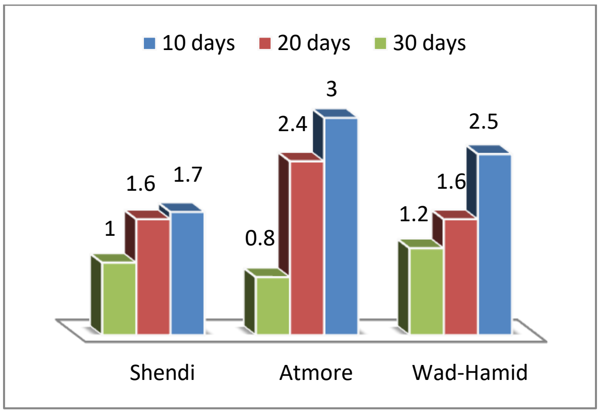

Fig.3. Effect of water interval on number of branches/ plant of chickpea cultivars

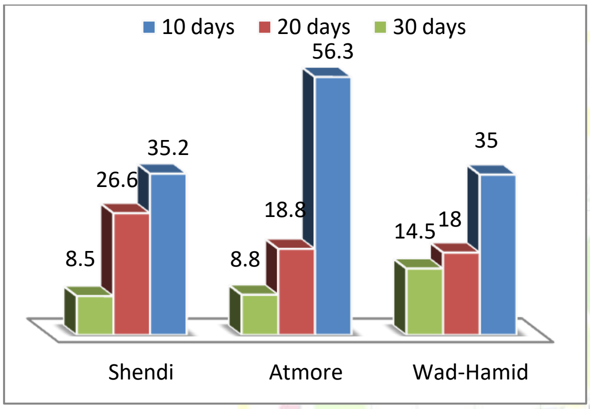

Fig.4. Effect of water interval on number of pods/ plant of chickpea cultivars

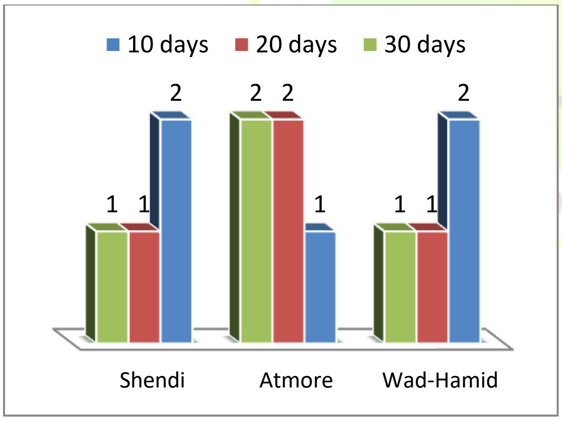

Fig.5. Effect of water interval on number of seeds per pod of chickpea cultivars

All cultivars displayed comparable number of branches. However, the differences between water intervals were significant. Chickpea cultivars irrigated after 10 days increased number of branches per plant significantly, as compared to irrigation every 20 and 30 days (Fig. 3). Result showed that branches number was significantly affected by irrigation intervals. The highest and lowest number of branches was record in Atmore cultivar at 10 and 30 days irrigation respectively. However, (Ahmed,

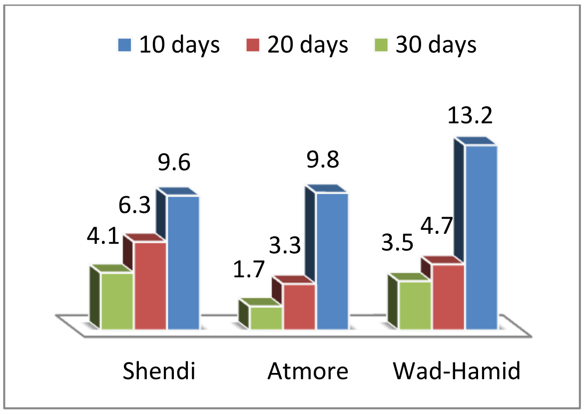

Fig.6. Effect of water interval on weight of pods/ plant of chickpea cultivars

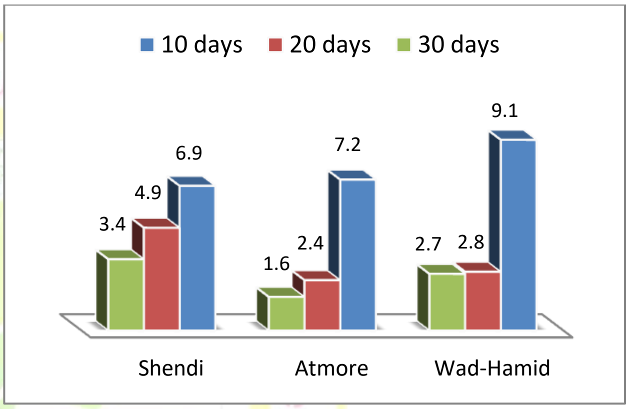

Fig.7. Effect of water interval on weight of seeds/ plant of chickpea cultivars

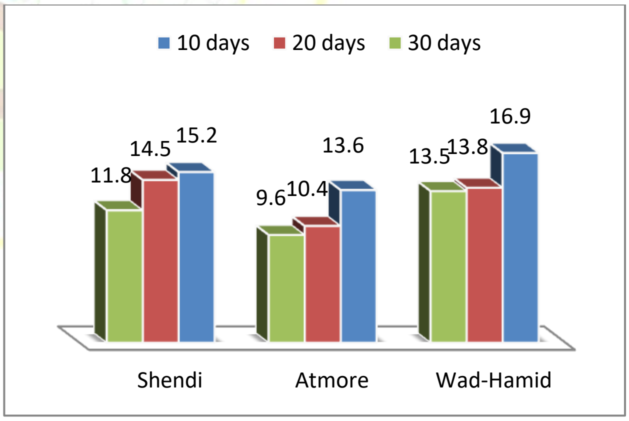

Fig.8. Effect of water interval on hundred seed weight of chickpea cultivars

2006) reported that no significant differences between chickpea cultivars in branches number, and this may be due to genetic character.

Different cultivars irrigated after 10 days sustain the highest pods number, followed by 20 and 30 days. Results showed that no significant difference was observed in number of pods per plant between chickpea cultivars (Fig. 4). Result displayed that

number of pods per plant decreased significantly with the increase in water intervals. The highest number of pods per plant was observed in 10 days intervals in Atmore (late flowering) than Wad Hamid and Shendi (early flowering). Similar results were reported by (AllaJabow, *et. al*., 2015).

Water intervals affect significantly number of seeds/ pod. As general, irrigation chickpea cultivars every 10 days displayed greater number of seeds/pod, followed by 20 days interval. Increasing water interval to 30 days reduced the number of seeds /pod significantly (Fig. 5). The weight of pods displayed an average of 13.2 g, 9.8 g and 9.6 g / plant due to Wad-Hamid, Atmore and Shandi respectively at 10 days water interval. Increasing water interval to 20 days decreased weight of pods /plant, but not significantly, as comparison to 10 days interval. A further increase in water interval to 30 days decreased weight of pods significantly, as compared to 10 days interval (Fig. 6). With respect to yield and yield component results showed that number of seeds per pod and hundred seed weight were significantly affected by irrigation intervals and cultivars. Moreover, irrigation interval was highly significantly affected on number of pods / plant, weight of pods / plant and weight of seeds / plant. Irrigation every 10 days gave the highest record in these characters. Interaction between irrigation intervals and cultivars were not significant in all characters except in number of seeds / pods, and this may referred to genetic characters.

Cultivars Wad-Hamid and Atmore at 10 days water interval gave highest weight of seeds / plant, while increasing water intervals to 20 and 30 days decreased seeds weight significantly. Shendi cultivar at the lowest water interval (10 days) displayed 5.0 g seeds weight /plant. Increasing water intervals to 20 and 30 days reduced seeds weight / plant, but not significantly, as comparison to 10 days interval (Fig. 7). Among the cultivars Wad-Hamid and Shendi had the highest and comparable hundred seed weight, while Atmore had the lowest. Irrigation interval at 10 days gave the highest 100 seed weight (15.3 g). Increasing water intervals to 20 and 30 days decreased 100 seed weight / plant significantly to 12.9 g and 11.7, respectively (Fig. 8). There were significant difference in number of seeds / pod and 100 seed weight; the highest weight of 100 seed was obtained from Wad Hamid in 10 days interval. The highest number of seeds / pod was recorded from Shendi cultivar in 10 days intervals, and the lowest number of seed / pod was obtained from Wad Hamid cultivar in 30 days intervals. There were significant reduction in weight of pods / plant and weight of seeds / plant when water interval increased. This trend was similar to the number of pods / plant. The highest values of these traits obtained with 10 days intervals; whereas the lowest values recorded under severe water condition (30 days interval). Availability of water will maintain continuous filling of assimilate in the seeds.

According to the results findings obtained from this study it can be concluded that chickpea crop irrigated every 10 days gave the best in plant height, number of leaves, number of tillers, number of pods /plant, weight of pods /plant, number of seeds /pod, weight of seeds /plant, and weight of 100 seed irrespective to the cultivars. Among all cultivars, Atmore cultivar sustained the best cultivar as compared to other cultivars. Further studies are needed to study the effects of different organic and inorganic fertilizers on chickpea yield and yield components under water intervals.

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Research Article

Influence of seed rate and NPK fertilizer on yield and quality of Rhodes grass (*Chloris gayana* L. kunth.)

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ABSTRACT

A field experiment was conducted during summer season of 2007 at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat, Sudan, to investigate the effect of seed rate and NPK fertilization on yield and quality of Rhodes grass forage (*Chloris gayana* L. Kunth) cv. Finecut. The treatment consisted of three seed rates (SDR1, SDR2 and SDR3) namely 5, 10 and 15 kg/ha and three NPK fertilizer levels (F0, F1 and F2) namely 0, 120 and 240 kg/ha respectively. NPK fertilizer components were N17 P17 K17. The experiment was laid out in a Factorial CRBD with four replications. The results showed that seed rate significantly increased forage fresh and dry yield. NPK fertilization significantly increased forage fresh and dry yield. Neither seed rate nor NPK fertilization were significantly affected crude protein and fiber content of leaves and stems of Rhodes grass, but the increase in seed rate and fertilizer levels slightly increased crude protein and decreased fiber percentage. Seed rate ×NPK fertilization interaction showed significant effect on crude protein and crude fiber contents. The highest protein percentage obtained under SDR2 (10kg/ha) with highest NPK fertilization level F2 (240 kg/ha), and lowest value obtained under SDR1(5kg/ha) with NPK fertilization F1(120kg/ha) and SDR1(5kg/ha) under control of fertilizer treatment (F0). Regarding crude fiber, highest value obtained under SDR2(10 kg/ha) with NPK fertilization F1 (120kg/ha) and SDR3 (15 kg/ha) under control treatments of fertilization (F0).
Keywords: *Rhodes grass, seed rates, NPK fertilizer, yield, quality*

INTRODUCTION

Forage production is gaining more attention in the tropics and the subtropics; in both developed and developing countries. Many new species, varieties and cultivars of forage and pasture plants have been introduced from different areas and countries rich in forage and pasture plant to areas where they are scarce. In Sudan forage production is very important because the forage is the basic source of energy for the growth and maintenance of livestock and increase their products, also due to the fact that Sudan has a huge number of animals which is estimated by about 143 million heads (goats 63 million, sheep 42 million, cattle 35 million and camels 3 million) in 1998 (Mohammed, 2000).

Overgrazing on natural pasture, expanding of rainfed agriculture on range land and improper conservation measures of the grazing land lead to reduction of rangeland. Most of the animals in Sudan are greatly dependent on the natural vegetation as their major source of feed for maintenance and production. This attitude is clearly reflected on poor output and performance of animals resulting from poor quality of forages and the problems of over and under grazing.

The possible solution to support the natural pastures is to establish and develop the irrigated pastures and encourage the utilization of agricultural by-products and crop residues that are produced in huge amounts for animals feeding in the Sudan. The most important forage crops cultivated under irrigation in Sudan are alfalfa, Abusabien (sorghum forage), Clitoria, Lubia, Phillipsara, Sudan grass and other forage crops like Rhodes grass which is grown in small areas around Khartoum; because the crop is introduced recently and the farmers did not know the importance and cultural practices of the crop. The total forage yield in Sudan estimated by about 105.2 million ton of dry matter (Abuswar and Drag, 2002); the natural rangeland shares about 78 million ton and irrigated forage produces about 4 million ton only and the crop residues provide about 21.8 million ton annually. Rhodes grass (*Chloris gayana* L. Kunth) has been a popular perennial grass in the tropics and the subtropics of east and southern Africa, Australia and Central America. The crop originated in eastern and southern Africa, and it's valued for its ability to cover ground, tolerance for drought, light frost, soil salinity

and suitability to be grown in association with many tropical legumes. The crop usually varies in organic compounds, crude protein 4-13%, crude fiber 30-40 %, ether extract 0.8-1.5 %, nitrogen-free extract 42-48 % and digestibility is 40-60 % of dry matter. Therefore, the crop is highly palatable to animals. Valenzuela and Smith (2002), described the benefits and uses of Rhodes grass as, excellent for erosion control and weed suppression, well for quick growth, although establishment may be relatively slow. Rhodes grass is cross-pollinating (Skerman and Riveros, 1990). Number of chromosomes are 2n=20, 30, 40 (Fedorov, 1974). The diploids (2n=20) include cvs. Pioneer and Katambora and the tetraploids (2n=40) include cvs. Callide and Samfrod. Breeding and selection aims at plants that are leafier and late flowering. Partirdge, (2003) described that two new varieties have been selected from Katambora and Pioneer for hay production for the Middle East market was (Finecut) is derived from Katambora and (Topcut) from Pioneer. Luna *et al.* (2002) pointed that the diploid and tetraploid cultivars are available in the market; the latter are more productive but also less salt tolerant.

According to FAO (2003), there are some other African varieties namely Giant Rhodes; Mbarara from Uganda, Rongai is grown near Nakuru; Kenya, Nzoia, Pokot and Masaba are grown in Kenya and Karpedo is suited to the drier areas of Kenya. Mclove *et al.* (1982), stated that *Chloris gayana* was adapted to lands down soil but it was the outstanding grass at that site. Harwood *et al.* (1999) reported that Rhodes grasshad poor emergence (4-5.5%) onmoderate- very strongly alkaline/ medium- high salinity class tertiary spoil soils. Ortega *et al.* (2006), pointed that salinity have harmful effect on growth of Rhodes grass Seedling leaves and elongation on successive days, this is due to reduced hydraulic conductance in salt-stressed plants.Ehrlich *et al.* (2003) reported that Rhodes grass cultivars are not greatly harmed by pests and diseases. *Chloris gayana* can be used as fresh forage or in the form of silage,but utilization as hay and green forage is the major use. According to FAO, (2003) the crop makes quite good hay if cut just as it begins to flowering or a little earlier. Old stand give low quality hay. Silage has been made successfully in Nigeria, Zambia and Northern Australia, but generally it does not give satisfactory silage.In Zambia Rhodes grass alone yielded 58 DM ton/ha. Under irrigation in Texas, yield of dry matter is 15.775ton/ha was recorded. In South-West Australia a yield of 23.639 ton/ha was obtained from an irrigated Rhodes grass pasture treated with three dressings of fertilizer, each dressing providing 56, 22, 45 kg/ha of Nitrogen, Phosphorus and Potassium, respectively (FAO, 2003). Duke (1983), found that the dry matter yield was 15.5-17.2 MT/ha annually in Florida, U.S.A, and higher yields reported when planted in 25 cm rows and fertilized with 150 kg N/ha.Gherbin*et al.* (2007), showed that *Chloris gayana* yielded high dry matter in warm-season areas when grown with others species of grasses and showed values ranging from 16.4 to 21.1 ton/ha. Abudiek (1980) found that Rhodes grass resulted in the highest yield from mixture of grasses with butter fly pea and phillipesara in Sudan. Ehrlich *et al.* (2003) pointed that reducing the frequency and total volume of irrigation resulted in a reduced level of soil water and pasture yields of Rhodes grass.

Phosphorus plays an important role in photosynthesis processes to produce protein and remobilization of sugar to starch. On the other hand, phosphorus enhances reproductive growth, root growth and make stem strong to prevent plants lodging (Burhan and Hago, 2000). Grof (1980), reported that Rhodes grass was classified as medium phosphorus requirer. Crowder and Chheda (1982), and Mclover (1984), found that tiller and leaf number of Rhodes grass increased with increase in phosphorus rates, but the increase was much greater for tillers than leaves. Geweifel (1997), in Egypt found that application of phosphorus favoured the growth of sorghum plants as expressed in more height, leaf area, plant dry weight, leaf to stem ratio, number of tillers/m², and fresh and dry forage yields of sorghum. Regarding forage quality results indicated that crude protein % was significantly increased with phosphorus application up to 31kg P2O5/fed. Abbas (2003), and Gasim (2001), found that crude protein increase with phosphorus application. Abbas, (2003) showed that crude fiber decreased with addition of phosphorus. Plants need a large amount of potassium, however, potassium not enters in composition of organic matter, but it plays an important role in physiological processes of plant. (Burhan and Hago, 2000).Wilkinson and Langdale (1976), showed that a spilt application of nitrogen is superior to large single application in producing yield of warm season grasses. Henzell (1971), reported that nitrogen fertilization caused a significant increase in the nitrogen content of soil, roots and dry matter of Rhodes grass. Cowan *et al.* (1995) stated that the increases in pasture yield of Rhodes grass are at a maximum when nitrogen applied to pastures. Saeed (1988), found that dry matter production of pre harvest samples and final harvest increased significantly under higher levels of nitrogen in fodder sorghum. Similar result was stated by (Adam, 2004; Elawad, 2004; Gasim, 2001; Skerman, 1990; Soliman, 2005; and Sawi, 1993).Wilkinson and Langdale (1976), reported that large quantities of potassium are required to replace K removed in harvested forage and to offset potential leaching losses because of the greater mobility of potassium. FAO (2003), stated that Rhodes grass early gives a response to potash in some area in the presence of nitrogen and phosphorus. Smith (1974), pointed that the amount of potassium required to achieve maximum growth was progressively reduced as the level of sodium application was increased in Rhodes grass grown in relatively high saline soils. Potassium application did not affect shoot dry matter (SDM) in soils having maximum clay content because this soil is rich in available K and have more potassium fixing capacity (Abdulwakeel, 2005).

MATERIAL AND METHODS

The study was carried out at the Demonstration Farm of Faculty of Agriculture, University of Khartoum; Shambat, Sudan during the summer season of 2007. The objective of the study was to investigate the effect of seed rate and NPK fertilization on yield and quality of Rhodes grass forage (*Chloris gayana* L. Kunth) cv. Finecut. The soil is a typical clay soil of the Central Clay Plain. (Saeed, 1988) described this soil as deep cracking moderately alkaline clays with pH 7.5-8. The experiment comprised of nine treatments which include three seed rates (5, 10 and 15 Kg/ha) of Rhodes grass cultivar Fine cut and three levels of NPK fertilizer levels namely (0,120 and 240Kg/ha). Experimental design used was a factorial with CRBD with four replications. The experimental area was disc ploughed, followed by disc harrowing to crush clods and then levelled. Ridging was done after levelling. The size of individual plot was (4×5 meters). Each plot consisted of five ridges, five meter in length and 70 cm apart. The field was irrigated before sowing to crush clods to ensure a fine seed bed. The seed was sown broadcasting using three seed rate in row done by hand about one centimetre deep on the middle of the ridge. The sowing date was 8th of April, 2007. After sowing the field was uniformly irrigated to ensure optimum germination and uniform crop establishment. After germination the crop was irrigated every ten days interval. NPK fertilizer was applied on the growing side of the ridges in lines after 21 days from sowing date in one dose at the three treatment levels (control F0 0kg/ha, F1 120kg/ha and F2 240 kg/ha). The parameters measured were leaf to stem ratio, forage fresh weights and forage dry weights ton per hectare, the data was collected at 30, 60 and 70 (at harvest) Day after sowing (DAS). In addition to that proximate analysis was performed on the dry weight samples to estimate forage quality in form of crude protein and crude fiber according to A.O.A.C. (1995) in the final harvest when the samples from forage dry yield were oven dried and grinded. The data were statistically analyzed using SAS statistical analysis software package, as a factorial design, by the Standard Analysis of Variance Techniques (Gomez and Gomez, 1984). Means separation was performed by Duncan's Multiple Range Test (DMRT) procedure.

RESULTS AND DISCUSSION

Leaf- to stem ratio:

The results showed that seed rate and NPK fertilizer were not significantly affecting leaf- to stem ratio (Table 1). NPK fertilization × seed rate interaction for leaf-to stem ratio was also not significant at the first sampling, but the second one showed significant effect as shown in Table 2.The highest leaf-to stem ratio obtained at second seed rate SDR2 and second fertilizer level F1.

Forage yield

Forage fresh weight (ton/ha):

The effect of seed rate and NPK fertilization on forage fresh yield is shown in Table 3. During all sampling occasions there was no significant difference in forage fresh yield between the different levels of seed rate, except at the second sampling occasion, where there was a significant effect at age of two months.

Table 1 The effect of seed rate and NPK fertilization on leaf -to stem ratio of Rhodes grass at different sampling occasions during 2006/2007

Sampling occasions	1stSampling (30DAS)	2ndSampling (60 DAS)
Seed rate Treatments ➘		
SDR1	11.643a	2.3775a
SDR2	10.873a	2.5892a
SDR3	10.795a	2.535a
NPK fertilizer Treatments ➘		
F0	11.941a	2.5075a
F1	13.028a	2.6358a
F2	8.342a	2.3583a
Means	11.1	2.5
C.V%	35.5	15.7

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT

Table 2 Seed rate × NPK fertilization interaction for leaf-to stem ratio at age of 30 and 60 days during 2006/2007

NPK fertilizer Treatments➥	F0	F1	F2
Seed rate Treatments ➘	1st sampling occasion (60 DAS)		
SDR1	12.11a	15.4a	7.43a
SDR2	12.04a	12.41a	8.17a
SDR3	11.68a	11.28a	9.44a
2nd sampling occasion (60 DAS)			
SDR1	2.518ab	2.423ab	2.193b
SDR2	2.503ab	2.81a	2.46ab
SDR3	2.503ab	2.68ab	2.423ab

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT

The effect of NPK fertilization on forage fresh yield was significant at all sampling occasion, except the last sampling at harvest. Seed rate × NPK fertilization interaction for forage fresh weight was significant at all cuts, except the last one (Table 5).

Forage dry weight (ton/ha):

As shown in Table 4, forage dry yield of Rhodes grass was not significantly influenced by seed rate, except the second sampling occasion which was significant at age of 60 days. However, NPK fertilization significantly influenced forage dry weight at the second sampling occasion. It was observed that dry forage yield increased with the increase in NPK fertilization level. The result also indicated that dry matter yield increased with increase in seed rate, except the last sampling occasion. Seed rate × NPK fertilization interaction for forage dry yield was significant at first and second sampling occasions as shown in Table 6. The highest forage dry yield was obtained at higher seed rate (SDR3) with higher level of NPK fertilization (F2).

Table 3 The effect of seed rate and NPK fertilization on forage fresh yield (ton/ha) of Rhodes grass at different sampling occasions during 2006/2007

Sampling occasions	1st sampling (30 DAS)	2nd sampling (60 DAS)	3rd sampling At harv.70 DAS
Seed rate Treatments↓			
SDR1	6.731a	24.648b	36.997a
SDR2	6.874a	30.17a	32.97a
SDR3	8.445a	30.32a	36.826a
NPK fertilizer Treatments			
F0	6.198b	24.733b	32.757a
F1	7.279ab	27.458b	35.144a
F2	8.574a	32.95a	38.892a
Means	7.34997	28.3805	35.5975
C.V%	36.4	19.9	26.7

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT

Forage quality:

Crude protein per cent:

The effect of seed rate and NPK fertilization on crude protein content of leaf and stem is presented in Table 7. The effect of seed rate on crude protein was not significant at (P>0.05). There is slight increase in crude protein however, with increasing seed rate. Seed rate SDR3 produced higher crude protein than SDR2 and SDR1. Regarding NPK fertilization also had no effect on crude protein. The lowest crude protein was recorded under the control treatment (F0), and the highest crude protein scored under high NPK fertilization level (F2).Seed rate × NPK interaction for protein content was significant (Table 8). The highest value of protein content was obtained at the seed rate (SDR2) 10 kg/ha under the highest NPK fertilization level (F2) 240kg/ha, while the lowest value was obtained at seed rate (SDR1) 5 kg/ha under (F1) NPK fertilization level (120 kg/ha).

Table 4 The effect of seed rate and NPK fertilization on forage dry yield (ton/ha) of Rhodes grass at different sampling occasions during 2006/2007

Sampling occasions	1st sampling (30 DAS)	2nd sampling (60 DAS)	3rd sampling At harv. 70 DAS
Seed rate Treatments ↓			
SDR1	1.1143a	6.5882b	10.386a
SDR2	1.1167a	7.9191ab	9.457a
SDR3	1.4644a	8.3286a	9.971a
NPK fertilizer Treatments ↓			
F0	1.1024a	6.8572b	9.481a
F1	1.1928a	7.25b	10.029a
F2	1.4001a	8.7287a	10.305a
Means	1.23	7.61	9.94
C.V%	36.0	21.15	26.55

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Table 5 Seed rate × NPK fertilization interaction for forage fresh weight at age of 30, 60 and 70 days (at harvest) during 2006/2007

NPK fertilizer Treatments →	F0	F1	F2
Seed rate Treatments ↓	1st sampling occasion (30 DAS)		
SDR1	4.6858b	7.7713ab	7.7358ab
SDR2	7.1928b	7.0288b	6.4003b
SDR3	6.7143b	7.0355b	11.586a
	2nd sampling occasion (60 DAS)		
SDR1	22.6420c	24.9153c	26.3863c
SDR2	25.4718c	29.623abc	35.4158ab
SDR3	26.0858c	27.836bc	37.0488a

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Crude fiber per cent:

The influence of seed rate and NPK fertilization on leaf and stem crude fiber content of Rhodes grass is presented in Table 7. The data showed that neither seed rate nor NPK fertilization affected leaves and stem crude fiber content of Rhodes grass. The lowest crude fiber was recorded under the second seed rate (SDR2), while the highest was obtained under (SDR3).Seed rate × NPK fertilization interaction for crude fiber was significant (Table 8). The highest crude fiber was obtained at SDR2 and F2. While the lowest one was recorded at SDR2 under control treatment (F0).

Table 6 Seed rate × NPK fertilization interaction for forage dry weight at age of 30, 60 and 70 days (at harvest) during 2006/2007.

NPK fertilizer Treatments ➥	F0	F1	F2
Seed rate Treatments ➘	1st sampling occasion (30 DAS)		
SDR1	0.8785b	1.229b	1.2358b
SDR2	1.2b	1.1143b	1.0358b
SDR3	1.2288b	1.2358b	1.9288a
	2nd sampling occasion (60 DAS)		
SDR1	5.9785c	6.393c	7.393bc
SDR2	6.9073bc	7.857abc	8.993ab
SDR3	7.6858abc	7.5abc	9.8a

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Table 7 The effect of seed rate and NPK fertilization on crude protein and crude fiber content of *Chloris gayana* at harvest 70 DAS during 2006/2007.

Parameters	Crude protein %	Crude fiber %
Seed rate Treatments➘		
SDR1	7.543a	30.718a
SDR2	8.765a	30.516a
SDR3	8.787a	30.808a
NPK fertilizer Treatments➘		
F0	7.9a	29.88a
F1	8.15a	31.346a
F2	9.05a	30.815a
Means	8.37	30.68
C.V%	17.4	9.4

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Table 8 Seed rate × NPK fertilization interaction for crude protein and crude fibre at harvest during 2006/2007

At harvest (70 DAS)			
NPK fertilizer Treatments➥	F0	F1	F2
Seed rate Treatments ➘	Crude protein %		
SDR1	6.69cd	6.4d	9.28a
SDR2	7.48cd	8.82ab	9.99a
SDR3	9.28a	9.21a	7.87bc
	Crude fiber %		
SDR1	30. 84ab	30.46b	30.85ab
SDR2	26.62c	31.82ab	33.11a
SDR3	32.19a	31.75ab	27.49c

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Leaf- to stem ratio

Leaf- to stem ratio neither affected by seed rate nor NPK fertilization as seen in the results. This observation is in accordance with those obtained by Gasim (2001) who reported that the increase in seed rate decrease leaf stem ratio. This due to the fact that high seed rate produce high plant population, this lead to competition between plants for nutrients, moisture and light which resulted in thin stem and narrow leaves for plants of high seed rate, therefore, leaf- to stem ratio was reduced. Regarding effect of the fertilizer on leaf to stem ratio, no significant effect showed, but there is slightly increase in leaf to stem ratio with increasing fertilization level in late stage of growth (second sampling). This could be due to the positive effect of the fertilization on growth of plants. As stated by Gasim (2001), the increscent in N fertilization led to increase in leaf to stem ratio. Geweifel (1997) also found that application of P favoured the growth of sorghum plants and produced more leaf to stem ratio.

Forage yield

The results revealed that higher seed rate increased forage fresh and dry yields of Rhodes grass compared to lower seed rate. The explanation of this result in the fact that high seed rate resulted in high number of plants per unit area therefore, high yield. This finding is in line with that reported by Koul (1997) who stated that forage fresh and dry yield were substantially increased under the highest seed rates. Also this result is in conformity with the finding of other investigators (Abusuwar, 1997; Adam, 2004; Gasim, 2001; Nour, 2004 and Luca *et al*, 2001).

It was also found that the increase in NPK fertilizer level resulted in high forage yield (fresh and dry forage yield) compared to the control. This is attributed to the fact that nitrogen increases the photosynthetic capacity of growing plants, which enhances growth to produce adequate dry matter. It is observed from the results of growth attributes, the fertilizer increased number of leaves per plant, plant fresh and dry weight, and leaf area index. Consequently higher yield could be expected at higher NPK fertilization level. This finding is in agreement with the finding of several research workers about the effect of nitrogen and phosphorus on yield of different forage grasses (Cowan *et al*, 1995; Koul, 1997; Seaed, 1988; Skerman and Riveros, 1990; Soliman, 2005; Sawi, 1993; Geweifel, 1997; Mohammed, 1990; Buerkert*et al*, 2001 and Abbas, 2003).

Forage quality:

In this work forage quality was determined in term of crude protein content and crude fiber of whole plant (leaves and stems).Increasing NPK fertilization led to slight increase in crude protein percentage. This result emphasized the fact that nitrogen plays a great role in synthesis of protein. Also phosphorus plays an important role in photosynthesis processes to produce protein and remobilization of sugar to starch. Similar

results regarding the increased crude protein due to fertilizer application were obtained by several researchers. Kaftas, (1990) reported that nitrogen fertilization increased the crude protein of Rhodes grass by about 15% at the early stage of growth, but the percentage reduced at advanced growth stage (advance in maturity). Also Adam, (2004) observed that nitrogen improved forage quality by increasing crude protein of teff grass. Other similar results were obtained by Eltelib, (2004); Gasim, (2001); Koul, (1997) and Soliman, (2005). Moreover, Abbas, (2003) and Gasim, (2001) found that crude protein increased with phosphorus application. With regard to the effect of seed rate on crude protein percentage, was found not significant, but there was very small increase in crude protein with increasing seed rate. This result is in accordance with those reported by Adam, (2004) who summarized that increase in protein percentage of teff grass was observed as seed rate increased. Similar result was reported by Gasim, (2001) when he analysed the quality of forage maize.

Crude fiber was not significantly affected by either seed rate or NPK fertilizer. The crude fiber has relatively constant value at different seed rate of Rhodes grass, but the fertilization level F1 resulted in the highest crude fiber content than F2. This result is in agreement with finding of Gasim, (2001) who reported that increase in N levels reduced fiber content of maize forage. Adam, (2004); Abbas, (2003); and Koul, (1997) reported similar results on effect of nitrogen. And Abbas, (2003) showed that crude fiber decreased with addition of phosphorus. Similar result is reported by Abusuwar (2005).

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Research Article

Evaluation of different post-emergence herbicides in chickpea (*Cicer arietenum* L.)

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ABSTRACT
A field experiment was conducted during *rabi* season of 2018-2019 at research farm of Bihar Agricultural University, Sabour, Bhagalpur to assess the effect of various post-emergence herbicides in chickpea. The results indicated that among different herbicides, post-emergence application of imazethapyr + imazamox @ 60 g a.i. ha^{-1} at 20 days after sowing recorded significantly lowest weed density & weed dry weight at 60 days after sowing and highest weed control efficiency at harvest, which was statistically at par with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} at 20 days after sowing. As a consequence of effective weed control, quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} at 20 days after sowing recorded significantly highest grain yield, straw yield and harvest index which was significantly superior over hand weeding twice at 30 and 50 days after sowing. In weedy check, uncontrolled weed growth caused significant reduction in grain yield of chickpea. Net returns and B:C ratio was found maximum with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} at 20 days after sowing which was significantly superior over weedy check.
Key words: *Chickpea, Economics, Post emergence herbicide, Weed flora, Yield*

INTRODUCTION

Chickpea (*Cicer arietinum* L.), commonly known as gram or Bengal gram is a legume of Asian origin. It is considered a third important food legume and second important pulse. It is widely cultivated in whole India and stands the first rank in pulse area and production in India. In Bihar, it is cultivated in 0.60 lac hectares with a production of 0.68 lac tonnes and productivity 1124 kg ha^{-1} (Anonymous, 2018).

The productivity of chickpea is relatively very low due to many constraints i.e. biotic and abiotic elements. Poor weed management practice is the most yield-limiting factor in chickpea. Weeds can remove the nutrients from the soil more effectively than the crops. Being slow in early vigour and shortened plant, chickpea is highly vulnerable to crop-weed competition leads up to 75% losses in yield due to weeds (Chaudhary *et al*., 2005). Initial 60 days is considered as the period that is too critical for crop-weed competition in chickpea (Singh and Singh, 2000). Under these unfavorable conditions of severe losses caused by the weeds, difficulties in hand weeding, and susceptibility of chickpea to many herbicides, it is imperative to evolve some effective/economical methods of weed control which can effectively adjust with the situation.

In India, besides pendimethalin, a large number of new herbicides i.e. imazethapyr, imazamox, clodinafop-propargyl, quizalofop-ethyl have been available in the market for better weed control associated with pulses and have no any adverse effect on the performance of the crop. Since the action of the herbicide is considerably influenced by the type of soil, nature of crop, dose, and time of application against specific weeds for a particular locality, it will be a practical guide to the farmers.
This present investigation, was, therefore planned at Bihar Agricultural University farm, Sabour during *rabi* 2018-19 with a view to study the relative efficacy of different post-emergence herbicides either alone or in combination with other herbicides at appropriate dose and time of application on growth, the yield of chickpea and associated weeds than hand weeding.

MATERIAL AND METHODS

A field experiment was carried out during *rabi*, 2018-2019 at research farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar to assess the efficiency of different post-emergence herbicides in chickpea. The soil of the experimental plot was sandy

loam with neutral soil pH (7.43), low in available nitrogen (191.88 kg ha^{-1}) and medium in available phosphorus (22.62 kg ha^{-1}) and potassium (192.88 kg ha^{-1}). Experiment was laid out in randomized block design with three replications. The treatments consisted of twelve weed management practices *viz.*, **T_1**- Pendimethalin 30 EC @ 1000 g a.i. ha^{-1} as PE, **T_2**- Oxyfluorfen 23.5 EC @ 150 g a.i. ha^{-1} as PE, **T_3**- Quizalofop-ethyl 5 EC @ 50 g a.i. ha^{-1} as PoE, **T_4**- Imazethapyr 10 SL @ 50 g a.i. ha^{-1} as PoE, **T_5**- Imazethapyr 35% + Imazamox 35% WG @ 60 g a.i. ha^{-1} as PoE, **T_6**- Clodinafop-propargyl 8% + Sodium-acifluorfen 16.5% EC @ 60 g a.i. ha^{-1} as PoE, **T_7**- Propaquizafop 10 EC @ 100 g a.i. ha^{-1} as PoE, **T_8**- Topramezone 33.6 SC @ 40 g a.i. ha^{-1} as PoE, **T_9**- Clodinafop-propargyl 8% EC + Imazethapyr 10% SL @ 60+50 g a.i. ha^{-1} as PoE, **T_{10}**- Quizalofop-ethyl 5% EC + Imazethapyr 10% SL @ 60+50 g a.i. ha^{-1} as PoE, **T_{11}**- Two hand weeding @ 30 and 50 DAS and **T_{12}**- Weedy check. Chickpea cv. GCP-105 was grown on November 10, 2018 with seed rate (80 kg ha^{-1}) and spacing (30 x 10 cm). Crop was uniformly fertilized with 20:40:00 kg N: P_2O_5: K_2O ha^{-1} and entire dose of N and P_2O_5 was applied as basal.

Data on weed density, weed dry weight, and weed control efficiency at 30, 60, 90 days after sowing, and at harvest stage were recorded by 0.5 x 0.5 m size quadrate. Weed control efficiency was worked out on the basis of weed dry matter using the formula suggested by Mani *et al*. (1973). The normality of distribution was not seen in the case of observations on weeds. Hence the values were subjected to square root transformation $\sqrt{x+0.5}$ before statistical analysis to normalize the distribution. Data on grain yield, straw yield, and harvest index were recorded. Economic analysis of data was also done using the cost of inputs and selling price of produce obtained after processing of harvested material. All the data were statistically analyzed using F-test procedure. Critical difference value at P=0.05 were oftenly used to determine the significance of differences between treatment means.

RESULTS AND DISCUSSION

Weed flora

Weed flora present in the experiment during 2018-19 was collected and grouped as broad-leaved weeds, grasses, and sedges. *Cynodon dactylon* L. and *Dactyloctenium aegyptium* L. are grasses. *Cyperus rotundus* L. is sedge. Among broad-leaved weeds, *Euphorbia hirta* L., *Chenopodium album* L., *Solanum nigrum* L., *Amaranthus viridis* L., *Vicia hirsuta* L., *Vicia sativa* L., *Polygonum plebeium* L., *Anagallis arvensis* L., *Argemone mexicana* L., *Melilotus indicus* L., *Fumaria parviflora* and *Coronopus didymus* L.

Table 1: Total weed density (No. m^{-2}), weed dry weight (g m^{-2}) and weed control efficiency (%) as influenced by different weed control treatments

S. No.	Treatments	Weed density (No. m^{-2})		Weed dry weight (g m^{-2})	
		30 DAS	60 DAS	30 DAS	60 DAS
T_1	Pendimethalin @ 1000 g a.i. ha^{-1} PE	5.27 (27.33)	6.20 (38.00)	1.37 (1.37)	4.85 (23.03)
T_2	Oxyfluorfen @ 150 g a.i. ha^{-1} PE	5.39 (28.67)	6.49 (41.67)	1.39 (1.43)	5.07 (25.25)
T_3	Quizalofop-ethyl @ 50 g a.i. ha^{-1} at 20 DAS	7.56 (56.67)	6.34 (39.67)	1.83 (2.83)	4.95 (24.04)
T_4	Imazethapyr @ 50 g a.i. ha^{-1} as at 20 DAS	7.34 (53.33)	5.93 (34.67)	1.78 (2.67)	4.63 (21.01)
T_5	Imazethapyr+Imazamox @ 60 g a.i. ha^{-1} at 20 DAS	7.24 (52.00)	4.52 (20.08)	1.76 (2.60)	3.50 (11.75)
T_6	Clodinafop-propargyl+Sodium-acifluorfen @ 60 g a.i. ha^{-1}at 20 DAS	7.69 (58.67)	5.73 (32.43)	1.85 (2.93)	4.49 (19.65)
T_7	Propaquizafop @ 100 g a.i. ha^{-1} at 20 DAS	8.40 (70.00)	7.09 (49.73)	2.00 (3.50)	5.54 (30.14)
T_8	Topramezone @ 40 g a.i. ha^{-1} at 20 DAS	6.96 (48.00)	5.40 (28.67)	1.70 (2.40)	4.23 (17.37)
T_9	Clodinafop-propargyl+Imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS	6.61 (43.33)	4.98 (24.33)	1.63 (2.17)	3.90 (14.75)
T_{10}	Quizalofop-ethyl+ Imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS	6.59 (43.00)	4.82 (22.83)	1.63 (2.15)	3.78 (13.84)
T_{11}	Two hand weeding at 30 and 50 DAS	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_{12}	Weedy check	8.99 (80.33)	11.19 (124.67)	2.12 (4.02)	8.72 (75.55)
SEm ±		0.15	0.13	0.03	0.20
CD (P=0.05)		0.46	0.40	0.10	0.60

Weed density and weed dry weight

Data pertinent to total weed density at 30 and 60 days after sowing was significantly influenced by various weed control treatments and is presented in Table 1.
At 30 days after sowing, among weed control treatments, hand weeding twice at 30 and 50 DAS (T_{11}) recorded significantly minimum weed density per m^2 (0.71) whereas weedy exhibited maximum weed density per m^2 (8.99). Among herbicidal treatments, minimum weed density per m^2 (5.27) was recorded with pendimethalin @ 1000 g a.i. ha^{-1} (T_1) being at par with oxyfluorfen @ 150 g a.i. ha^{-1} (T_2) and was found significantly lower over rest of the treatments. At 60 days after sowing, among weed control treatments, hand weeding twice at 30 and 50 DAS (T_{11}) recorded significantly minimum weed density per m^2 (0.71) whereas weedy exhibited maximum weed density per m^2 (11.19). Among herbicidal treatments, minimum weed density per m^2

(4.52) was recorded with imazethapyr + imazamox @ 60 g a.i. ha^{-1} at 20 DAS (T_5) being at par with quizalofop-ethyl + imazethapyr @ 60+50 g a.i.ha^{-1} (T_{10}) and was found significantly lower over rest of the treatments. Hand weeding treatment indicated complete control of weeds was only possible manually. This is in conformity with the findings of Singh and Singh (2005).

Weed dry weight

Data pertaining to weed dry weight at 30 and 60 days after sowing was significantly influenced by different weed control treatments and is presented in Table 1.

At 30 days after sowing, hand weeding twice at 30 and 50 DAS (T_{11}) recorded significantly minimum weed dry weight per m^2 (0.71) whereas weedy exhibited maximum weed dry weight per m^2 (2.12). Among herbicidal treatments, minimum weed dry weight (1.37) was recorded under pendimethalin @ 1000 g a.i.ha^{-1} (T_1) being at par with oxyfluorfen @ 150 g a.i. ha^{-1} (T_2) and was found significantly lower over rest of the treatments.

At 60 days after sowing, among weed control treatments, hand weeding twice at 30 and 50 DAS (T_{11}) recorded significantly minimum weed dry weight per m^2 (0.71) whereas weedy exhibited maximum weed dry weight per m^2 (8.72). Among herbicidal treatments, minimum weed dry weight was recorded with imazethapyr + imazamox @ 60 g a.i. ha^{-1} at 20 DAS (T_5) being at par with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS (T_{10}) and clodinafop-propargyl + imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS (T_9) and was found significantly lower over rest of the treatments.

At 30 and 60 days stage, weedy check recorded significantly highest weed counts and dry weight that was mainly due to higher and uninterrupted growth of weeds that made best utilization of resources. On the other hand, lowest weed counts and dry weight was noted in hand weeding treatment recorded zero value than rest of the treatments at 30 and 60 days stages that might be attributed to control of weeds manually at 30 and 50 days intervals, which resulted in reduced dry matter accumulation by weeds. These results are in conformity with the findings of Rajib *et al.* (2014) and Chandrakar *et al*. (2015).

Weed control efficiency

Weed control efficiency was calculated at harvest on the basis of weed dry weight and expressed as %. Data related to weed control efficiency was significantly influenced by different weed control treatments and is presented in Table 2. At harvest, among weed control treatments, hand weeding twice at 30 and 50 DAS (T_{11}) recorded maximum weed control efficiency (96.53%) whereas weedy check registered zero value. Among herbicidal treatments, maximum weed control efficiency (80.01%) was recorded with imazethapyr + imazamox @ 60 g a.i. ha^{-1} at 20 DAS (T_5) being at par with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS (T_{10}) and was significantly superior over rest of the treatments. Poonia and Pithia (2013) also reported efficient weed control in chickpea through herbicide mixtures. Higher weed control efficiency might be attributed due to lower weed counts and weed dry weight. These results corroborated with the findings of Butter *et al.* (2008). However, lower weed control efficiency was recorded with weedy plot which was largely due to higher weed counts and weed dry weight. These results corroborated with the findings of Sharma (2009) and Singh *et al*. (2008).

Table 2: Weed control efficiency, grain yield, straw yield and harvest index of chickpea as influenced by different weed control treatments

S. No.	Treatments	Weed control efficiency (%)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	Pendimethalin @ 1000 g a.i. ha^{-1} PE	62.38	14.58	21.54	40.38
T_2	Oxyfluorfen @ 150 g a.i. ha^{-1} PE	61.08	14.40	21.47	40.18
T_3	Quizalofop-ethyl @ 50 g a.i. ha^{-1} at 20 DAS	45.42	12.94	19.43	39.96
T_4	Imazethapyr @ 50 g a.i. ha^{-1} as at 20 DAS	61.13	14.04	21.41	39.62
T_5	Imazethapyr + Imazamox @ 60 g a.i. ha^{-1} at 20 DAS	80.01	11.88	18.35	39.32
T_6	Clodinafop-propargyl + Sodium-acifluorfen @ 60 g a.i. ha^{-1} at 20 DAS	63.71	15.39	21.77	41.41
T_7	Propaquizafop @ 100 g a.i. ha^{-1} at 20 DAS	47.02	12.46	19.43	39.05
T_8	Topramezone @ 40 g a.i. ha^{-1} at 20 DAS	66.28	15.83	22.10	41.75
T_9	Clodinafop-propargyl + Imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS	74.71	15.93	22.13	41.85
T_{10}	Quizalofop-ethyl + Imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS	77.02	17.11	22.32	43.40
T_{11}	Two hand weeding at 30 and 50 DAS	96.53	17.52	24.58	41.67
T_{12}	Weedy check	0.00	11.52	18.17	38.84
SEm ±		1.14	0.60	0.85	1.41
CD (P=0.05)		3.42	1.75	2.57	NS

Grain yield

Data on grain yield of chickpea was significantly influenced by different weed control treatments and are presented in Table 2. Among weed control treatments, hand weeding twice at 30 and 50 DAS (T_{11}) recorded highest grain yield (17.52 q ha^{-1}) of chickpea which was statistically at par with quizalofop-ethyl 5 EC + imazethapyr @ 60+50 g a.i. ha^{-1} PoE (T_{10}), clodinafop-propargyl + imazethapyr @ 60+50 g a.i. ha^{-1} PoE (T_9) and topramezone @ 40 g a.i. ha^{-1} PoE (T_8) and was significantly superior over rest of the treatments including a weedy check (11.52 q ha^{-1}). It was largely due to reduced weed crop competition in these treatments, however, weedy check exhibited their lower value.

Table 3: Effect of different weed control treatments on economics in chickpea

S. No.	Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1	Pendimethalin @ 1000 g a.i. ha^{-1} PE	27121	77051	49930	1.84
T_2	Oxyfluorfen @ 150 g a.i. ha^{-1} PE	26521	76190	49669	1.87
T_3	Quizalofop-ethyl @ 50 g a.i. ha^{-1} at 20 DAS	27556	68526	40970	1.49
T_4	Imazethapyr @ 50 g a.i. ha^{-1} as at 20 DAS	26706	74499	47793	1.79
T_5	Imazethapyr + Imazamox @ 60 g a.i. ha^{-1} at 20 DAS	27017	63143	36126	1.34
T_6	Clodinafop-propargyl+Sodium-acifluorfen @ 60 g a.i. ha^{-1}at 20 DAS	26620	80898	54278	2.04
T_7	Propaquizafop @ 100 g a.i. ha^{-1} at 20 DAS	27206	66309	39103	1.44
T_8	Topramezone @ 40 g a.i. ha^{-1} at 20 DAS	32156	83094	50938	1.58
T_9	Clodinafop-propargyl + Imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS	27393	83571	56178	2.05
T_{10}	Quizalofop-ethyl + Imazethapyr @ 60+50 g a.i. ha^{-1} at 20 DAS	28866	89077	60211	2.09
T_{11}	Two hand weeding at 30 and 50 DAS	33466	92002	58536	1.75
T_{12}	Weedy check	25756	61399	35643	1.38
SEm ±		-	2782	2782	0.10
CD (P=0.05)		-	8160	8160	0.29

Straw yield

Data pertinent to the straw yield of chickpea was significantly influenced by various weed control treatments and are presented in Table 2. Maximum straw yield (24.58 q ha^{-1}) was recorded under hand weeding twice at 30 and 50 days after sowing which was found at par with T_{10}, T_9, and T_8 and was significantly superior over rest of the treatments including the weedy check which registered significantly lowest straw yield (18.17 q ha^{-1}).

Harvest Index

Data on the harvest index under the influence of various weed control treatments are presented in Table 3. Data revealed that none of the weed control treatments have any significant effect on harvest index of chickpea though the maximum harvest index (43.40%) was registered with T_{10}.

Gross returns

A perusal of data in Table 3 revealed that the highest gross returns (Rs. 92002 ha^{-1}) was recorded with hand a weeding twice at 30 and 50 DAS (T_{11}) and lowest gross returns (Rs. 61399 ha^{-1}) was recorded with weedy check (T_{12}). Among herbicidal treatments, the highest gross returns (Rs. 89077 ha^{-1}) were recorded with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} (T_{10}) which was at par with clodinafop-propargyl + imazethapyr @ 60+50 g a.i. ha^{-1} PoE (T_9) and topramezone @ 40 g a.i. ha^{-1} PoE (T_8) and was significantly superior over rest of the treatments.

Net returns

Data on net return was significantly influenced by various weed control treatments and are presented in Table 3. The data revealed that significantly the highest net return (Rs. 60211 ha^{-1}) was accrued with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} (T_{10}) which was mainly due to higher gross returns recorded in this treatment as a consequence of higher economic yield of chickpea. This was at par with hand weeding twice at 30 and 50 DAS (T_{11}), clodinafop-propargyl +imazethapyr @ 60 + 50 g a.i. ha^{-1} PoE (T_9) and clodinafop-propargyl + sodium-acifluorfen @ 60 g a.i. ha^{-1} PoE (T_6) and was significantly superior over rest of the treatments where it was largely due to lower economic yield of chickpea.

Benefit: cost ratio

Data on benefit: cost ratio as calculated from net return and cost of cultivation of each treatment and was significantly influenced by different weed control treatments and is presented in Table 3. Highest benefit: cost ratio (2.09) was found with quizalofop-ethyl + imazethapyr @ 60+50 g a.i. ha^{-1} PoE (T_{10}) which was found at par with clodinafop-propargyl + imazethapyr @ 60+50 g a.i. ha^{-1} PoE

(T_9), clodinafop-propargyl + sodium-acifluorfen @ 60 g a.i. ha^{-1} PoE (T_6), oxyfluorfen @ 150 g a.i. ha^{-1} as PE (T_2) and pendimethalin @ 1000 g a.i. ha^{-1} as PE (T_1) which was mainly due to higher economic yield and net returns in these treatments and was significantly superior over rest of the treatments and weedy check which showed dissimilarity among themselves. This was largely due to higher phyto-toxicity of imazethapyr + imazamox @ 60 g a.i. ha^{-1} (T_5) reduces the plant population in weeding operations though this attained low economic yield. This result is in conformity with the findings of Singh and Vaishya (2001).

From the results of present investigation, it may be concluded that application of imazethapyr+ imazamox @ 60 g a.i. ha^{-1} at 20 days after sowing recorded significantly lowest weed density & weed dry weight at 60 days after sowing and highest weed control efficiency at harvest, being at par with quizalofop-ethyl+ imazethapyr @ 60+50 g a.i. ha^{-1} at 20 days after sowing which also recorded significantly highest grain yield, net returns and B:C ratio in chickpea.

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Review Article

Life style of fungi from Biotrophy to Necrotrophy and Saprotrophy

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ABSTRACT

Plant pathogenic fungi causes' economic menace to crop production throughout the world. On the basis of their life styles they may be classified as biotrophs, hemibiotrophs and necrotrophs. For biotrophs it is mandatory to thrive on living host cell and tissues and often found to secrete a little amount of cell wall degrading enzymes and certain effector molecules for suppressing plant host defense mechanism. Necrotrophs survive on dead host cell and tissues which are killed by them before or during infection. Hemibiotrophs in their early stage of life behave as biotrophs and become necrotrophs on later. This article represents the evolution of biotrophs, interaction of biotrophs, hemibiotrophs and necrotrophs with their host plant and continuum of life styles from biotrophy, through to necrotrophy and ultimately to saprotrophy.
Keywords: *Biotrophs, hemibiotrophs, necrotrophs, evolution, effector*

INTRODUCTION

Plant pathogenic fungi have adopted a variety of life styles, from necrotrophy (see Glossary), actively killing the host (Ottmann *et al*., 2009), to obligate biotrophy showing systemic, almost asymptomatic growth (Ploch and Thines, 2011). Obligate biotrophs can become devastating plant pathogens via reproducing through repeated asexual or sexual cycles. Through sexual recombination or somatic hybridization genetic variation is maintained among the population. Based on their morphology during asexual reproduction, obligate leaf pathogens were historically classified as either rusts or mildews, releasing spores in patches through a ruptured epidermis or form conidiophores on the leaf surface respectively. Since, De Bary's first report of biotrophic infection structures in 1863, a wealth of knowledge has accumulated about rusts and mildews caused by both fungi and oomycetes. The recent sequencing of the most important groups of biotrophic plant pathogens, that cause fungal powdery mildews (Spanu *et al*., 2010) and rusts (Duplessis *et al*., 2011), and oomycete downy mildew (Baxter *et al*., 2010) and white rusts (Kemen *et al*., 2011; Link *et al.*, 2011) represents a new opportunity and dimension to lookinto the life style of these pathogens in an evolutionary context. Here we discuss obligate biotrophy and consequences of this life style; similarities and differences of host penetration; the haustorium as a hallmark of biotroph pathogens; and to what extent horizontal gene transfer (HGT) might have influenced the evolution of rust and mildew like pathogens.

EVOLUTION OF BIOTROPHS

Between 1700 and 1200 million years ago (Mya), the ancestors of fungi and oomycetes diverged (Porter, 2004; Chernikova *et al.*, 2011). Oomycetes belong to the clade of stramenopiles, together with brown algae and diatoms, whereas fungi are members of the opisthokonts together with animals (Baldauf, 2008). It is found that evolution of many stramenopiles (previously part of the chromalveolates) involved secondary endosymbiosis with red algae and possibly even green algae (Kemen *et al.*, 2011; Moustafa *et al.*, 2012). Traces of green- and red-algal genes can be identified within stra-menopile genomes (Kemen *et al.*,

GLOSSARY

Biotrophs: 'Obligate parasites developing on another organism, in a personal relationship with its cytoplasm' (The Dictionary of the Fungi, 2001). 'Growths that develop and replicate in living plant tissue while acquiring nutrients through close interactions with living plant cells' (Latijnhouwers et al., 2003). 'Fungi that have absolute reliance on the host to finish their life-cycle, getting nutrients from living host cells by separation of specific contamination structures called haustoria' (Divon and Fluhr, 2006). 'Pathogens that practice to benefit from living plant tissues and some have built up a close relationship with their host plant' (de Wit, 2007). 'Fungi that don't slaughter their hosts and require living cells for development, co-pick homeostasis in the host to create an advantage for the fungus' (Dickman and de Figueiredo, 2011). 'Parasites that get vitality from living cells and are obligate parasites meaning they can't live without their host, have haustoria, don't secrete abundant lytic enzymes and cause little harm to the host plant' (Kemen and Jones, 2012). 'Pathogens that get nutrients from live host cells and produce effectors to supress the basal plant protection and form appressoria to infect epidermal cells produce cell wall degrading enzymes, hyphae to draw the nutrients, and sporulate without killing host cells' (Pandey *et al.,* 2016). for examples powdery mildews (*Blumeria spp.),* downy mildews, rusts.

Hemibiotrophs: 'Fungi that at first build up a biotrophic relationship with their host however along these lines, the host cells kick the bucket as the contamination continues' (Latijnhouwers *et al.*, 2003). 'Fungi that at first form a relationship with living cells of the host, much like a biotroph, and afterward in the later phases of contamination they become necrotrophic, effectively executing host cells' (Plant Pathology Glossary, 2003). 'Fungi having an underlying time of biotrophy followed by necrotrophic hyphae' (Oliver and Ipcho, 2004). 'Fungi that render its host to a great extent alive while building up itself inside the host tissue with brief biotrophic-like stage and later changing to a necrotrophic way of life' (Divon and Fluhr, 2006). 'Organisms that are parasitic in living tissue for quite a while and afterward keeps on living in dead tissue' (Wiktionary, 2016) e.g. *Magnaporthe grisea, Bipolaris sorokiniana, Phytophthora infestans.*

Necrotrophs: 'Pathogens that execute and feed off the dead tissue. All evident necrotrophic pathogens at first have a biotrophic stage in which they asymptomatically colonize the host tissues' (Spanu *et al.*, 2012). 'Pathogens that cause rapid cell death in has and evoke major molecular reactions from the plant and they have wide host ranges and secrete abundant lytic enzymes and poisons' (Meinhardt *et al.*, 2014) e.g. *Pyrenophoratritici-repentis (*tan spot*), Stagonosporanodorum (septorianodurum* blotch*).*

Endophytes: 'All living beings occupying plant organs that eventually in their life can colonize internal plant tissues without causing apparent harm to the host' (Hyde and Soytong, 2008).

Saprotrophs: Organism that feeds on decaying organic matter or dead tissues' (Spanu *et al.*, 2012).

2011; Moustafa *et al.*, 2012). It is still debated and quite confusing if in stramenopiles that do not contain endosymbionts (i.e., non-photosynthetic stramenopiles), algal genes were acquired by HGT or such genes were derived from ancient endosymbionts that were mostly lost during evolution (Stiller *et al.*, 2009; Maruyama *et al.*, 2009). It is believed that convergent evolution led to filamentous organisms, with the ophistokonts and stramenopiles, (around 1500 Mya, Chernikova *et al.*, 2011) and oomycetes (1000–700 Mya, Bhattacharya *et al.*, 2009), respectively. Filamentous fungi and oomycetes evolved parasitic life styles in aquatic systems, infecting various algae (Li *et al.*, 2010; Vischer *et al.*, 2011). Between 850 and 450 Mya, ancestral fungi diverged into the Glomeromycota, Ascomycota and Basidiomycota (Berbee and Taylor, 2010). During this period of radiation, around 600 Mya, fungi started to colonize terrestrial habitats (Redecker *et al.*, 2000), followed by the first land plants around 450 Mya (Rensing *et al.*, 2008). Early land plants relied on close interactions with fungal and fungal-like organisms to colonize their new habitat (Humphrey *et al.*, 2010).

Fossils dating back about 400 Mya show that plants had already evolved defense mechanisms such as encasement layers around intercellular hyphae to defend themselves from filamentous pathogens (Krings *et al.*, 2007). In the period of about 450 million years of co-evolution between plants and pathogens or symbionts, plants faced high selection pressure to refine their non-self-recognition capabilities in order to detect, defend and survive pathogen pressure (Jones and Dang, 2006) while still maintaining beneficial symbioses. Conversely, pathogens and symbionts has also faced high selection pressure to avoid recognition or to suppress host defense, leading to a nonstop arms race between plant colonizing organisms and their hosts (Boller and He, 2009; Ravens *et al.*, 2011). With the advancement in genome sequencing of current obligate biotrophs are being expected the outcome of such evolution. Biotroph ascomycetes like the pathogen *Blumeria graminis*, causing powdery mildew on barley (*Hordeum vulgare*), or the symbiont *Tuber melanosporum*, the Perigord black truffle, show a substantial genome expansion compared to necrotrophic or saprophytic fungi, primarily due to increased transposable element (TE) abundance (Spanu *et al.*, 2010; Martin *et al.*, 2010). In *B. graminis* an increase in loss of genes required for repeat induced point mutations (RIPs) and TE abundance has been observed and has been discussed as a possible hypothesis (Spanu *et al.*, 2010). RIP renders TEs and other duplications within the genome dysfunctional and therefore inhibits spread of TEs. Lack of RIP has been

suggested to be a potential advantage for pathogens, because it could speed up evolution due to genome re-arrangements after TE insertions and gene duplications (Oliver and Greene, 2009). Abundant transposons have also been identified in the genome of the hemibiotroph oomycete *Phytophthora infestans*, where gene sparse regions rich in TEs and repeats have been identified as parts of the pathogen genome where effector genes for host pathogen interaction are found (Haas *et al.*, 2009). Although *P. infestans* most likely lacks RIP, TEs and genes are likely to be silenced by RNA interference (RNAi) (Vetukuri *et al.*, 2011), an important defense mechanism against viruses that leads to degradation of viral RNA (Obbard *et al.*, 2009). Fast reorganization of genome due to gene duplication and TEs might be one mechanism by which some pathogens can speed up their habitation to hosts but paradoxically in other pathogens, like the causal agent of blackleg disease on Brassica crops (*Leptospaeria maculans*), RIP promotes rapid sequence diversification that likely promotes pathogen adaptation (Rouxel *et al.*, 2011). Although some biotroph basidiomycetes, such as rust fungi show an increase in genome size compared to non-pathogenic basidiomycetes (Dupleesis *et al.*, 2011), they have a lower proportion of TEs than biotroph ascomycetes. A similar trend of observation in size differences can be seen in oomycetes also. While the downy mildew pathogen of *Arabidopsis thaliana*, *Hyaloperonospora arabidopsidis*, has an increased genome size correlated with many TEs (Baxter *et al.*, 2010), the genomes of oomycetes that cause white rust on *A. thaliana* (*Albugo laibachii*), and white rust of Brassica crops (*Albugo candida*) are significantly smaller. For the biotroph smut fungus on corn (*Ustilago maydis*) neither RIP nor any other mechanism to inhibit spread of TEs has been identified, yet the genome is small with low numbers of TEs (Kamper *et al.*, 2006). So we can say that sequencing genomes of different taxa revealed different mechanisms that might be due to genome size and effector evolution. Comparing genomes of organisms with rust like phenotypes to those with mildew like phenotypes within their respective phylogenetic group of fungi or oomycetes, reveals that a smaller genome is more often found in rust-like than mildew-like organisms. An exception might be the causal agent of soybean rust (*Phakopsora pachyrhizi*) with an estimated genome size of more than 700 Mbp (http://www.osti.gov/bridge/servlets/ purl/860744-7ClNx8/860744.pdf). As very few species have been sequenced so far and genome size estimates need to be validated, such findings can only suggest early indications, but will influence thinking about which organisms should be sequenced next. Comparative genomics between fungi and oomycetes might reveal new mechanisms for effector evolution and for regulation of TEs and gene duplications within these genomes. Obligate biotrophy, life styles from parasitism to mutualism. Although the first plant fungal interactions may have been symbiotic (Humphrey *et al.*, 2010) it is debatable if pathogenic interactions that we observe today evolved from mutualistic interactions or if each evolved independently. Phylogenetic studies suggest that pathogenicity and there-fore biotrophy evolved independently in different phylogenetic clades of fungi and oomycetes (Thines and Kamun, 2010; Mclaughlin *et al.*, 2009), excluding the hypothesis of a common ancestor of biotrophic pathogens. The availability of genomes of pathogen and symbionts such as the ectomycorrhizal basidiomycetes *Laccaria bicolor* (Martin *et al.*, 2008) or the ascomycete *T. melanosporum* (Martin *et al.*, 2010) enables us to investigate these important evolutionary questions. The genome sequence of *L. bicolor* (Martin *et al.*, 2008), revealed a significant number of genes conserved with the biotroph corn smut fungus *U. maydis* and a significant reduction in cell wall degrading enzymes like cellulases (Martin and Selose, 2008) that might suggest a conserved mode of host cell penetration or recognition avoidance between symbionts and pathogens. Electron microscopy on rust fungi reveals anclose interaction between host and pathogen mediated by haustoria, highly differentiated hyphae that penetrate the cell wall, but stay separated from the host cytoplasm by a differentiated plant plasma membrane (Mendgen *et al.*, 1991). With genome sequences of obligate biotroph organisms available it became apparent that biotrophic organisms show loss of biosynthetic pathways (Spanu *et al.*, 2010; Baxter *et al.*, 2011; Kemen *et al.*, 2011). We can therefore hypothesize that obligate biotrophic pathogens depend on their host, because they lack the ability to synthesize important metabolites (Spanu *et al.*, 2010; Baxter *et al.*, 2011; Kemen *et al.*, 2011). It is therefore not surprising that most attempts to grow and propagate obligate biotroph pathogens on complex culture media have failed (Voeglee and Mendgen, 2011) and if growth was observed in rare cases, growth was extremely impaired (Williams, 1984). A most common property of biotrophs is their ability to make host cells susceptible to pathogens that are otherwise not capable of growing on these hosts (Cooper *et al.*, 2008, Health 1983, Lyngkjaer and Carver 1999), suggesting highly effective host defense suppression. It has been proposed that there are certain effectors molecules that enable pathogens to grow in intimate interactions with their hosts permitting acquisition of sugars, amino acids and cofactors (Raffaele *et al.*, 2010). This leads to relaxed selection pressure in the biotroph pathogen to maintain biosynthetic pathways present in host plants and therefore relaxes selection against gene loss and host-

dependence (Kemen *et al.*, 2011). Independent loss due to effective host adaptation is further supported by the observation that not all obligate biotroph pathogens have lost the same biosynthetic pathways. For example *A. laibachii* and *B. graminis* lost the ability to synthesize vitamin B (Spanu *et al.*, 2010; Kemen *et al.*, 2011) while *Uromyces fabae*, the causal agent of bean rust retained these enzymes (Sohn *et al.*, 2000).

HORIZONTAL GENE TRANSFER

Similarities in virulence and lifestyle between biotroph fungi and oomycetes have long been thought to be a result of convergent evolution, with HGT playing a minor role (Latin *et al.*, 2003). HGT was first revealed between prokaryotes and nematodes, fungi or oomycetes and revealed that genes encoding for secondary metabolites have been transferred (Schmitt and Lumbsch 2009; Danchin *et al.*, 2010). Some of these pathways, such as the lipopolysaccharide biosynthesis that has been identified in oomycetes (Whittaker, 2009) might even change surface properties and pathogen recognition and therefore influence host range. However, oomycetes and other fungi belonging to two different eukaryotic kingdoms, there is evidence for gene transfer from fungi to oomycetes (Richards *et al.*, 2006). On the basis of these findings it has become apparent that HGT has a very great impact on pathogenicity and life style in oomycetes than previously expected (Richards *et al.*, 2011). In particular, a majority of genes acquired by HGT, such as numerous putative secreted lipases and mono- or di-oxygenases, are involved in either attacking or feeding on plant tissue (Richards *et al.*, 2011). In the oomycete *H. arabidopsidi*s, 21 putative fungal-derived genes were identified, with 13 gene products potentially secreted. These points towards a major impact of HGT on the secre-tome and effector complement of biotroph pathogens (Richards *et al.*, 2011). Within the white rust genome, only one fungal- derived gene has so far been identified. This gene shows close homology to a fungal rust protein with unknown function (Richards *et al.*, 2011). We speculate that the reason for not identifying more genes transferred from fungi into oomycete rusts is either the under representation of pathogenic basidiomycetes in the datasets or the lack of a successful integration of genes into the oomycete rust genome by horizontal transfer. The capacity of biotrophs to suppress defence to pathogens that would otherwise not be able to grow on the same host promotes growth of different biotrophs in close proximity. These intimate interactions might promote gene flow not only within species of populations, but also between species of different family. Not much about the exact mechanism of HGT between species is still unclear (Silva *et al.*, 2004).

EVOLUTIONARY PROCESS TO OBLIGATE PARASITISM

- Specialization of haustoria, expansion of effectors and suppressing host defenses.
- Loss of cellular apparatus, expansion of genome size and loss of functional genes.
- Loss of biosynthetic pathway and absolute dependence on the host.

Specialization of haustoria, expansion of effectors and suppressing host defenses:

Fossils show that close interactions between fungi and plants already involved host-cell-embedded arbuscules more than 400 Mya (Remy *et al.*, 1994). Arbuscules are effectively haustoria of symbiotic mycorrhizal fungi that penetrate through the plant cell wall, but stay separated from the host by the invaginated plant plasma membrane, evenafter branching and secondary growth within host cells. This membrane (the peri-arbuscular membrane) shows highly differentiated micro-domains containing symbiosis-specific proteins that are not present in normal plant plasma membranes, indicating specialization (Pumplin and Harrison, 2009). Comparable to arbuscules, haustoria of pathogenic fungi, rustfungi and mildews show secondary growth of haustoria within the host cell, whereas oomycetes haustoria do not shows such growth. Haustoria of biotrophic pathogens stay separated from the host cytoplasm by a membrane throughout their life. This membrane is called the extra haustorial membrane (EHMe).

Effectors are pathogen proteins, secreted in host apoplast or delivered into host cytoplasm to alter host response and suppression of host defense against invading pathogen e.g. *Ustilagomaydis –Hum 2, Hum-3, Pep-1, Magnaportheoryzae – AvrPita, PWL 1, PWL 2.* Effectors (red dots) are secreted into the apoplast, including the extra haustorial matrix, and must cross the extra haustorial membrane (a modified host plasma membrane) before entering the plant cytoplasm, where they may target host proteins to manipulate host metabolism, or can be recognized by host resistance proteins, resulting in the triggering of the host defense response.

A further task of haustoria is the delivery of effector proteins that accumulate within the EHM prior to crossing the EHMe into the host (Kemen *et al.*, 2005; Rafiqi *et al.*, 2010). The binding of effector proteins to

inositol-3-phosphate has been reported (Kale *et al.*, 2010; Yaeno *et al.*, 2011) and suggested as a mechanism involved in the transfer (Kale *et al.*, 2010) though the presence of phosphatidyl inositol-3-phosphatein the EHMe is still not proven. Additional mechanismsmay also occur such as tyrosine-O-sulphate dependent translocation which has been shown for an effector from the fish pathogen *Saprolegnia parasitica* (Wawra *et al.*, 2012). Effectors of different pathogens convergently evolved to target common hubs in the plant immune system (Mukhtar *et al.*, 2011), so a differential inter-atomic network analysis between rusts and mildews is perhaps most likely to reveal why rust fungiare more effective in suppressing defence than mildews and how this is correlated with their lifestyle. In summary, haustoria share many features, but thereare significant differences in intracellular growth between fungi and oomycetes. In terms of defense suppression, there is a significant difference between the causal agentsof mildews and rusts that might result from their penetration mechanism, but common core effectors cannot be excluded.

Loss of cellular apparatus, expansion of genome size and loss of functional genes:

It is being suggested that there is loss of proteins associated with zoospore formation and motility. Lack of adherent cysts is found that normally develop from zoospores during infection. In due course of time, the loss of flagellated spore stage, when fungi left aquatic systems to terrestrial habitats. *Example: Hyaloperonospora arabidopsidis* lost the ability to produce motile zoospores (*Albugo laibachii – white blister rust).* The **gene** encoding the flagellar internal arm dynein 1 substantial chain α is missing.

Gene losses in powdery mildews; Reduced number of genes devoted to secondary metabolism and genes encoding cellulose or hemicellulose degrading enzymes in *Blumeria*, *U. maydis* and *Puccinia graminis,* also possess reduced enzyme systems for degradation of the plant cell wall (cellulose, xylan, or pectin degrading enzymes). The most unexpected finding in sequencing the obligate biotrophic powdery mildew and rust fungi is the increase in size compared with close relatives that are either non pathogens or non biotrophs. In the oomycetes, this isn't the situation: **Obligate** biotrophs *H. arabidopsidis* and *A. laibachii* have genomes that are both altogether littler than those of related *Phytophthora spp.* larger genomes are not accompanied by larger numbers of structural genes. One possible explanation for this conundrum is that any increase is invariably the result of increased proliferation of transposable elements detectable as repetitive DNA, and that transposable elements can determine genetically heritable variation independently and additionally to sexual recombination (Biemont and Vieira, 2006). An increase in genetic polymorphism may have given competitive advantage to pathogens that need to adapt constantly to changes in host immunity brought about by natural selection in a prototypical Red Queen evolutionary scenario (Van, 1973). These advantages may be particularly acute in organisms such as the powdery mildews and the rusts, which rely on a rapid succession of asexual generations during their epidemics and thus miss out on the power of sexually induced recombination when it is most needed. There are alternative ways of generating variation. *M. graminicola* may have depended on the introgression of a dispensome as a vault of variation. The smuts have advanced a decreased genome size, however are obligate sexual organisms: Each round of contamination requires mating. At every generation, meiotic recombination has the capability of generating variation. Repetitive DNA is effectively excluded by the homologous recombination mechanisms, which are exceptionally developed toward eliminating repetitive DNA (Holliday, 2004). This makes their genomes highly streamlined. In the oomycetes, where there is no correlation between genome size and biotrophy, the effector genes and other genes involved in pathogenicity appear to be specifically contained in hyper variable areas of the genome (Hass *et al*., 2009; Raffaele *et al*., 2010).

The gene losses observed in a large number of the (obligate) biotrophs are then an outcome of dynamic retro transposition as observed in the regions of the *H. arabidopsidis* genome that are syntenic with the flagellum-related genes of zoosporicoomycetes (Kemen et al., 2011). These losses are at first tolerated in plant pathogens that no longer require certain functions (e.g., inorganic nitrogen uptake) but are essentially irreversible, in a manner very close to that described by Dollo’s law of irreversibility (Marshall *et al*., 1934). Once these losses include loss of the regulatory network capacity to adapt metabolism in the absence of a host (in axenic culture), biotrophs become obligate. This hypothesis now needs to be tested.

Loss of nitrate, nitrite reductase and nitrate transporter from the syntenic region of *Hyaloperonospora arabidopsidis from Phytopthora spp.* Similar gene loss also reported in rust fungi *Melampsora populinalarici* and *Puccinia graminis f. sp. tritici.* Powdery mildew fungi *Blumeria graminis*, *Erysiphepisi* and *Golovino mycesorontii.* Likewise loss of sulfite reductase in rusts was also reported in rust fungi *Melampsora populina larici* and *Puccinia graminis f.sp. tritici. (*Spanu *et al.*, 2010)

Loss of biosynthetic pathway and absolute dependence on the host:

The absence of various genes encoding enzymes and transporter required for the biosynthesis of various metabolites may also be the reason for this extraordinary biological compatibility. (de Wit, 2007; Meadows, 2011; Kemen and Jones, 2012; Delaye *et al.*, 2013; Guzman and Heil, 2014). The fungus *Albugo laibachii* the causal agent of white rust and *Hyaloperonospora arabidopsidis* causing downy mildew disease have lost the genes which codes for nitrogen and sulfur biosynthetic pathways (Meadows, 2011). Powdery mildew causing fungi such as *Blumeria spp*. have lost the genes encoding enzymes for anaerobic fermentation (pyruvate decarboxylase, alcohol dehydrogenase), biosynthesis of glycerol from glycolytic intermediates and biosynthesis of nitrate and thiamine (Spanu *et al.*, 2012; Spanu *et al.*, 2010) state that barley powdery mildew, *Blumeria graminis* and two other powdery mildew species, *Erysiphe pisi* causing powdery mildew on *Pisum sativum* and *Golovinomyces orontii* causing powdery mildew on *Arabidopsis thaliana*), have lost the genes encoding enzymes for primary and secondary metabolism, carbohydrate-active enzymes, and transporters. These missing genes are referred to as ‘missing ascomycete core genes' because they are found in other ascomycetes. Through various research it has been found that these missing genes are expressed in hemibiotrophic *Colletotrichum higginsianum* during its biotrophic phase (Spanu *et al.*, 2010). This suggests that, the lack or absence of 'missing ascomycete core genes' is must for biotrophs for e.g. fungi causing powdery mildew disease, but it is not so for hemibiotrophic fungi.

To obtain nutrients from the cells of host plants, many biotrophic fungi have evolved specialized hyphae haustoria. Haustoria are differentiated or specialized hyphae with spherical or lobed structures that penetrate the leaf mesophyl cell wall and grow adjacent to the plasma membrane, without entering into the cytoplasm (Latijnhouwers *et al.*, 2003; de Wit, 2007; Kemenand Jones, 2012; Delaye *et al.*, 2013; Kabbage *et al.*, 2015). Both *et al.* (2005) found that, in *Blumeria graminis* (powdery mildew of barley) haustoria take up glucose from the epidermal cells of plant to synthesize glycogen for the formation of conidia. In addition, some biotrophs have extra-haustorial membranes that separate the haustorium from the plant cytoplasm (Latijnhouwers *et al.*, 2003; Horbach *et al.*, 2011; Kemenand Jones, 2012). This type of nutrient absorbing system is important to acquire essential nutrients from the cytoplasm for nutrients enrich micro-environment (nutrient sink) between the haustorium and the host cell membrane (de Wit, 2007; Delaye *et al.*, 2013). Some endophytes such as *Disculaumbrinella* and *Rhabdoclineparkeri* however, produce haustoria during the early death of infected cells (Delaye *et al.*, 2013). For the colonization, fitness and assimilation of nutrient by fungi, the production of haustoria is very essential (Parniske, 2000; Divon and Fluhr, 2006; Kemen and Jones, 2012).

INTERACTIONS BETWEEN BIOTROPHS AND HOST PLANTS

Biotrophs have a close relationship with their host plants (Both *et al.*, 2005; de Wit, 2007; Gao *et al.*, 2010; Delaye *et al.*, 2013). Generally, a biotrophic fungus such as rust or powdery mildew pathogen are unable to grow in auxenic cultures or in lab and requires a living host to complete their life cycles (Parniske, 2000; Both *et al.*, 2005; Meadows, 2011). They have limited ability to synthesize cell wall degrading enzymes (Kabbage *et al.*, 2015). The fungi *Blumeria graminis* causing powdery mildew disease in barley has reduced production of carbohydrate active enzymes which is responsible for plant cell wall degradation (Spanu *et al.*, 2010). These fungi also produce various types of secondary metabolites which work as pathogenicity factors. Polyketide synthetases, modular non ribosomal peptide synthetases, terpenecyclases, and dimethyl allyl diphosphate tryptophan synthases are some of the key enzymes involved in the biosynthesis of secondary metabolites in fungi. Only two enzymes are however recorded from *Blumeria graminis* namely polyketide synthases and modular non ribosomal peptide synthetases (Spanu *et al.*, 2010). These facts indicate that biotrophic fungi have lost many genes for pathogenesis. These characters might be important keys to maintain long term interactions with living host plant cells, while avoiding detection of the fungus as a pathogen by the host plant (Micali *et al.*, 2008; Kemen and Jones, 2012).

INTERACTIONS BETWEEN HEMIBIOTROPHS AND HOST PLANTS

In contrast to biotrophs, hemibiotrophs have dual life-styles. They first establish biotrophic relationships with their hosts and subsequently switch to necrotrophic relationships (Oliver and Ipcho, 2004; Divon and Fluhr, 2006; Krola *et al.*, 2015). GAL4 like transcriptional activators in hemibiotrophs encoded by the CLTA1 gene are involved in reprogramming host cell metabolism and thereby switch the life-style from biotrophic to necrotrophic (Oliver and Ipcho, 2004; Krola *et al.*, 2015). The initial biotrophic lifestyle of

hemibiotrophs causes minimum damage to the plant tissues, while the fungus obtains nutrients from living plant tissues (Latijnhouwers *et al.*, 2003). Generally all hemibiotrophic fungi develop haustoria, but some also produce intracellular hyphae to absorb nutrients from the host cytoplasm (Oliver and Ipcho, 2004; Divon and Fluhr, 2006). Even though, the hemibiotrophic life-style later breaks down host cell walls through secretion of cell wall degrading enzymes and the fungi survive on the released nutrients (Latijnhouwers *et al.*, 2003; Kabbage *et al.*, 2015). They also produce extracellular hyphae between the host cells to facilitate nutrient assimilation (Latijnhouwers *et al.,* 2003; Oliver and Ipcho, 2004).

INTERACTIONS BETWEEN NECROTROPHS AND HOST PLANTS

Fungal diseases pose constant threats to the global economyand food safety. Being the largest group of plant fungal pathogens, necrotrophic fungi cause heavy crop losses all over the world. The molecular mechanisms of the interaction between necrotrophic fungi and plants are complex and involve sophisticated recognition and signaling networks. From the recent studies on necrotrophic fungi, the roles of phytotoxin and proteinaceous effectors pathogen-associated molecular patterns (PAMPs) and small RNAs has been comprehended. We also consider the functions of damage-associated molecular patterns (DAMPs), the receptor-like protein kinase BIK1, and epigenetic regulationin plant immunity to necrotrophic fungi. Toxin effectors from necrotrophic fungi can target a host's central signal regulator to trigger R gene-mediated resistance and to thereby increase host susceptibility to attack by necrotrophic fungi. Chitin, PGs, SCFE1, and other PAMP effectors secreted by necrotrophic fungi can be recognized by RLPs or RLKs, and such recognition triggers a series of PTI responses. Although necrotrophic fungi can secrete enzymes thatdegrade the host cell wall, some of the degradation products, i.e., DAMPs, act as elicitors that trigger host immune responses. By binding to the host RNAi machinery, small RNAs delivered by necrotrophic fungi into host cells can act as virulenceeffectors that suppress host immune responses. Although PAMPs/DAMPs are initially recognized by distinct upstream PRRs, the immune signaling pathways triggeredby those PRRs may converge on a central regulator like BIK1 and SOBIR1. By regulating the expression of defense genes, epigeneticmodifications, including DNA methylation and histonemodifications, play important roles in plant immunity to necrotrophic fungi.

SAPROPHYTIC FUNGI

The word saprophytic (sapro - rotten material, phyte - plant) is misnomer when fungi are considered, since fungi are not plants (this term was used before, when fungi were considered to be members of the plant kingdom). It would be better to say saprotrophic fungi. Saprotrophic fungi are those fungi that have an extracellular digestion mechanism for putrefying organic matter (originating from dead or decaying organisms) and in this way absorbing the essential nutrients for their growth and reproduction. Many fungal species are saprobes, in fact every species which is not a parasite or symbiont (which, in contrary, obtain nutrients from other living). Oyster mushrooms (*Pleurotus ostreatus*), shiitake mushrooms (*Lentinu laedodes*), Rhizopus, Mucor, Aspergillus, Penicillium, Agaricus, Morchella etc. are the examples ofsaprophytic fungi.

CONCLUSIONS

Biotrophy is a pervasive trait that evolved independently in plantpathogenic fungi and oomycetes. Ever expanding reservoirs of effectors will require us to locate the most essential targets for genetic resistance or chemical controls.Genes that are not necessary for growth on a plant disappeared, butwe still do not know what lost functions make some of these pathogens obligate. The evolution of biotrophs associated with expansion of genome with transposons and loss of genes coding for several nutrient metabolism and toxin production. The journey of evolution, they gained ways to overcome host defenses and losing the ability to make nutrients. Pathogen lost the ability of several metabolisms (N, S and thiamine), reduced expression secondary metabolism and gained several host-defense modification effectors resulting in biotrophic life style. The role of effector proteins in sustaining biotrophic interaction with the host cell and mechanism of manipulating host physiology need to be explored. Rapidly evolving effectors due to transposable elements and genome compartmentalization become serious threat to agro-eco system.Understanding the mechanisms of virulence is instrumental for designing management strategies.

The degree to which fungal and oomycetes rusts show similarities during host invasion, host colonization and asexual sporulation is not restricted to morphological features. Similarities can also be seen within the genome structure and the proteome. It is questionable whether these similarities are only due to convergent evolution and unknown to what extent HGT has contributed to similarities such as nutrient uptake and virulence mechanisms and what are the ways in which pathogens colonize their hosts. Rare transfer of genes from fungi to oomycetes is now clear, whereas gene

transfer from oomycetes to fungi remains to be demonstrated. It may be hypothesize that host

penetration through stomata might have an evolutionary advantage over direct penetration in terms of avoiding recognition. A high degree of gene loss in powdery mildews compared to other biotroph pathogens may reduce their capacity for adaptation even further. Sequencing further genomes will help to enable further and more robust insights into genome evolution of obligate biotroph pathogens.

From the above discussion it may be concluded that fungi exhibited continuum of life style from biotrophy to necrotrophy and ultimately to saprotrophy. However, it is still confusing and difficult task to place each and every fungus in a clear cut boundary. For better understanding of the life style more cytological, molecular studies, more genome sequencing and a better investigation of host pathogen interaction is required.

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